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REPORT ON OCEAN DUMPING RESEARCH AND DEVELOPMENT ATLANTIC REGION 1981-82

(PROCEEDINGS OF A WORKSHOP, JANUARY 18, 1983
HELD AT ST.ANDREWS BIOLOGICAL STATION, N.B.)

Edited by

G.A. PACKMAN

for

REGIONAL OCEAN DUMPING ADVISORY COMMITTEE (ATLANTIC)

ENVIRONMENTAL PROTECTION SERVICE

and

DEPARTMENT OF FISHERIES AND OCEANS

ENVIRONMENT CANADA
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ABSTRACT

A workshop was held on January 18, 1983 to review the results of research carried out under the auspices of the Ocean Dumping Research Fund in fiscal year 1981/82, and status reports for projects underway in fiscal year 1982/83. The papers presented dealt with topics including: the use of hydrographic sounding records for sediment facies mapping, an assessment of impacts from disposal of dredge spoils originating in Saint John Harbour, the bioavailability of cadmium and zinc from lead and zinc ore concentrates, the effects of ocean disposal on lobster ecology and habitat, the effects of the Miramichi Channel Dredging Project on winter water quality and fish populations within Miramichi Inner Bay. Some of the conclusions were that: Kelvin Hughes MS26B depth sounder records can be used as an inexpensive means of mapping sediment facies; lead and zinc from ore concentrates were bioavailable under the laboratory test conditions, depending upon the presence of sediment and organic matter, and changes in salinity. It would however, be inappropriate to extropolate the results to field conditions. Conclusions in other papers were that after one year, juvenile lobsters had failed to re-occupy a test site where 200 cubic meters of clean dredge spoil had been dumped; Miramichi Inner Bay winter water quality data suggested that dissolved oxygen and suspended particulate matter concentrations had returned to ambient levels after cessation of dredging in December; and, in the course of suction hopper dredging in the Miramichi River estuary the fine sediment fraction appears to have been dispersed into the water column. Progress was reported on the development of quality control criteria and methodologies for laboratory analyses and draft guidelines for participating laboratories in the Atlantic region are presented.

RESUME

Le 18 janvier 1983 se tenait un atelier au cours duquel on devait examiner les résultats de travaux de recherche effectués pendant l'année financière 1981-1982 sous le patronage du fonds de recherche sur l'immersion des déchets en mer, et des rapports d'avancement de travaux en cours en 1982-1983. Les documents présentés portaient notamment sur les sujets suivants: emploi de relevés de sondages hydrographiques pour établir la carte des faciès sédimentaires, évaluation des répercussions de l'élimination des déblais de dragage formés dans le port de Saint-Jean, biodisponibilité de cadmiun et de zinc dans les concentrés de minerai de plomb et de zinc, effets de l'élimination de déchets en mer sur l'écologie et l'habitat du homard, effets du projet de dragage du chenal de la Miramichie sur la qualité des eaux de la baie en hiver et sur les populations de poissons qui s'y trouvent. Voici quelques conclusions: on peut établir économiquement la carte des faciès sédimentaires à l'aide de relevés faits avec le sondeur MS26B de Kelvin Hughes; le plomb et le zinc issus de concentrés de minerai étaient disponibles dans les conditions d'essai en laboratoire, le tout dépendant de la présence de sédiments et de matières organiques et des modifications survenant au niveau de la salinité. Il n'y a, toutefois, pas lieu d'étendre par extrapolation les résultats aux conditions qui règnent sur le terrain. D'autres documents concluaient au fait que, après un an, les homards juvéniles n'avaient pas réoccupé un secteur expérimental où 200 mètres cubes de déblais de dragage propres avaient été immergés; les données sur la qualité des eaux de la baie Miramichi en hiver permettent de croire que l'oxygène dissous et les concentrations de particules de matière en suspension étaient revenus aux niveaux ambiants après l'interruption du dragage en décembre; et, il semble que, au cours des travaux de dragage de l'estuaire de la rivière Miramichi, travaux effectués à l'aide d'une drague porteuse à succion, la fraction de sédiments fins se soit dispersée dans la tranche d'eau. On signalait des progrès au chapitre de l'élaboration de critères de contrôle de la qualité et de méthodes d'analyse en laboratoire et on a présenté une ébauche de lignes directrices à l'intention des laboratoires participants de la région de l'Atlantique.

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1. INTRODUCTION

A.R. McIver
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As intended in its establishment, in the Atlantic Region the Ocean Dumping Research Fund has been used to generate information which can be applied to resolution of issues related to implementation of the Ocean Dumping Control Act. Funding support for research on these issues has been augmented by operational funds from both the Department of Environment (DOE) and the Department of Fisheries and Oceans (DFO).

In 1982 significant papers were presented at the Ocean Dumping Workshop, and the Proceedings were published in the Environmental Protection Service Surveillance Report Series (EPS-5-AR-82-1). Research results presented in those Proceedings and in other publications have led directly to the resolution of a number of management issues as outlined in the following examples.

Disposal of dredge spoils from Saint John Harbour, N.B. at the Black Point site had been suspected by the fishing community of having a major impact upon local fisheries through increased suspended sediment loading and habitat degradation. Research supported by the Ocean Dumping Research Fund demonstrated that ocean disposal at Black Point does not significantly add to the high ambient near bottom suspended sediment load and that problems in the fishery could not be related to use of the disposal site. Most material deposited at the Black Point Site which becomes re-suspended, is transported out into the Bay of Fundy away from local fishing areas.

At the Port of Dalhousie, N.B. the disposal method and the identification of a suitable dump site for dredge spoils contaminated with cadmium from a bulk lead/zinc concentrate loading facility has been an issue for several years. Papers presented at the 1982 workshop addressed the significance of the contamination and the suitability of the existing open water disposal site off Heron Island in the western Bay of Chaleur. A direct result of this research has been resolution of the issue in 1982 by containment of dredge spoils in nearby West Bay behind dykes built out of wood wastes from the nearby pulp mill.

In 1982 dredging of the Miramichi Shipping Channel was essentially completed. Details of the Permit requirements relating to avoidance of herring spawn were supported by work sponsored by the Research Fund. Also, while the project was monitored by the proponent, Public Works Canada, certain specific aspects, such as the study of herring avoidance of suspended sediment plumes, the effects of suspended sediment on smelt feeding behaviour, and evaluations of the stability of dump sites, were supported by the Research Fund. In this manner a more defensible assessment of the impacts of a major dredging and dumping project on an estuary with valuable fisheries resources has been possible, and this will provide a sound basis for future management decisions.

The proceedings of the 1982 workshop also detail progress towards laboratory quality assurance and the generation of meaningful and reliable analytical data upon which decisions may be based.

From the foregoing it is apparent that the Ocean Dumping Research program with additional support from DOE and DFO operational funds plays a crucial role in the effective administration of the Ocean Dumping Control Act. It is expected that this role will continue to be important and that quality information will continue to be produced as long as sufficient funds remain available. Regretably the value in terms of 1982 dollars has diminished significantly. It

is a tribute to those who have participated in this program that so much of the work funded has resulted directly or indirectly in the resolution of managment problems related to ocean disposal by the provision of the understanding and tools needed to carry out the intent of the Ocean Dumping Control Act to protect the marine environment.

2. THE USE OF ECHO SOUNDER RECORDS IN DETERMINING THE PHYSICAL SUITABILITY OF A DUMP SITE

D. Bezanson
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Occasionally it may be desirable to have dredge spoil deposited at a site where local forces will disperse it elsewhere. Usually, however the physical and chemical properties of the spoil are such that no one desires it in their backyard or on their favourite lobster grounds, and the lesser of all evils is to pick one spot in which the fewest persons have an interest, and establish that the material and its chemical constituents will stay there innocuously. Such a site requires, among other features, that local currents and waves be unable to erode freshly deposited dredge spoil. These forces have not been measured over most of the thousands of miles of Atlantic Canada's coastline, and to do so by conventional means at every potential dump site would be as expensive as it would be time consuming.

This study was conducted in the hope that existing depth sounder records obtained by the Canadian Hydrographic Service in the preparation of navigational charts for all heavily used commercial ports in the region, could provide this information, on the basis that the acoustic reflection properties of the bottom may be related to its grain size composition and then to its erodability. King (1966) reported the results of tests using Kelvin Hughes MS26B depth sounder records. It was reportedly possible to divide the textural features of the surface sediments of a portion of the Scotian Shelf into four groups with different particle size compositions. In the present study, Bay of Chaleur sediments have also been divided into four groups, although each group differs somewhat from King (1967). The groups used in this study are detailed in Table 1.

Table 1. Sediment Characteristic Groupings

Echo-Sounder Trace Characteristics	Particle Size Group
I Broad strong line without underlying features	Silt with some sand and clay
IIa Moderately strong line with some underlying features	Silt with more clay and some sand
II Weak bottom return with much penetration	Silt and clay together (mud)
III Narrow bottom return with no penetration	Predominantly sand

Figure 1 details echo-sounder tracks in the Bay of Chaleur which were examined in the course of this study while Figure 2 presents the sediment facies distribution which was developed from examination of records from these tracks.

In terms of sediment coarseness or average particle diameter, category II is the finest, followed by IIa, I and finally III as the coarsest, being composed of sand with some gravel. This sequence can be seen north of Heron Island with coarse to fine grading from shallow to deeper water, in the direction of the dump site. The sequence is repeated consistently along most of the coastline of the Bay. Also shown is the center line of a former river channel which is apparently filled by newly deposited fine sediment east of Heron Island, but scoured bare north and west of the island. The dump site lies just north of this channel in what seems to be a region of type I 3(a) sediment, or possibly IIa.

The implications of the map produced for this particular dump site generally support earlier management decisions to not relocate the site. Moving the dump site south to deeper water of the submerged river channel would place spoil in a region where some scouring may be occurring. The present Heron Island ocean dump site may be somewhat erosional, but to be sure of a substantial improvement in stability,

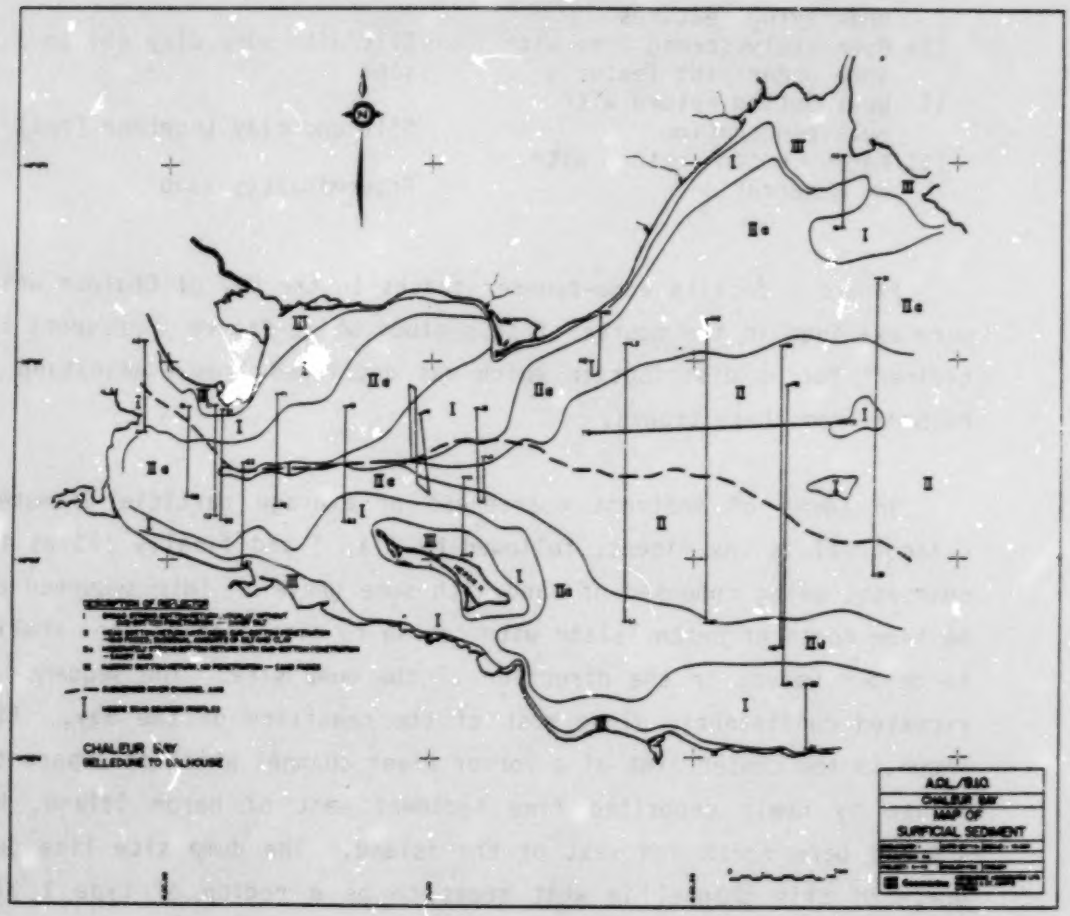

Figure 1. Tracks of echo-sounder surveys in Bay of Chaleur.

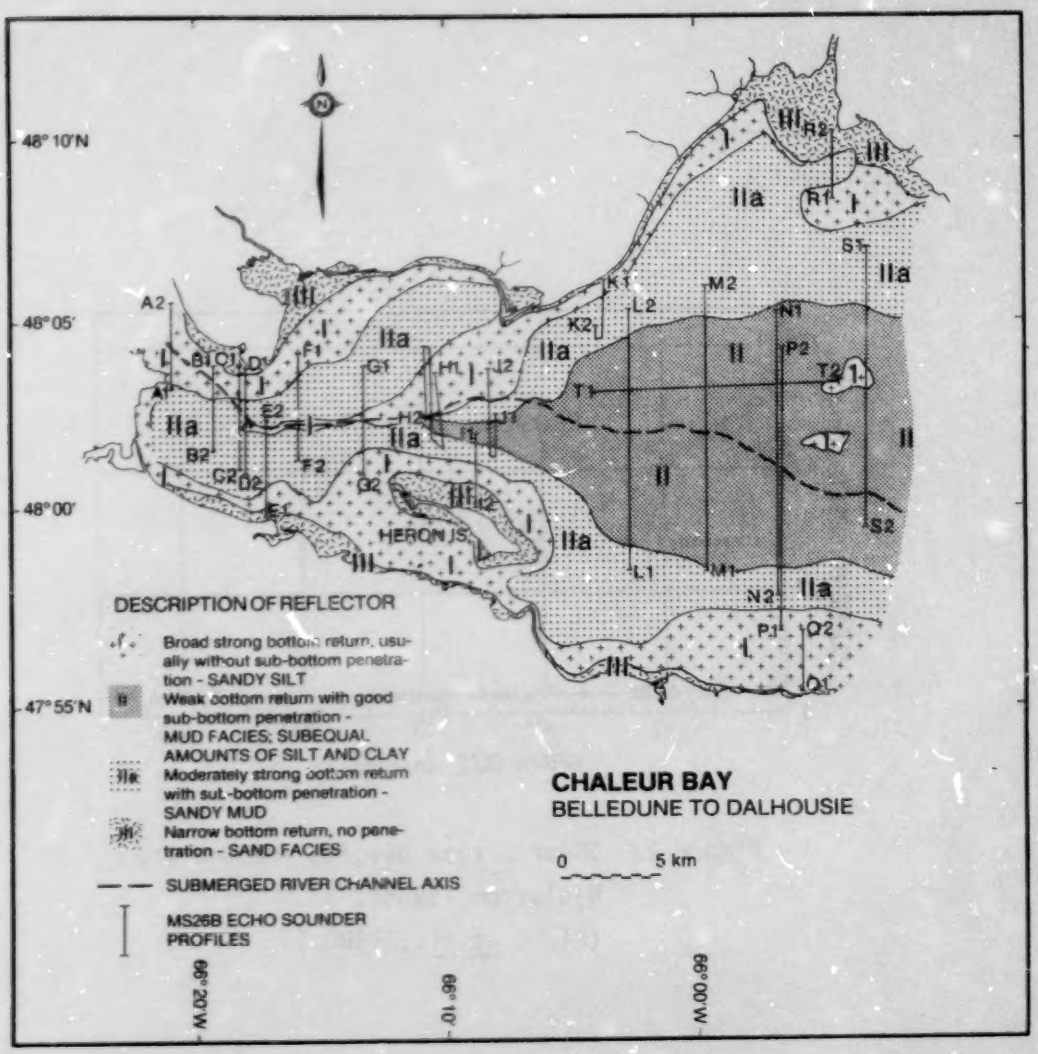
48° 10'N
48° 05'
48° 00'
47° 55'N
66° 20'W
66° 10'
66° 00'W
HERON IS.
DESCRIPTION OF REFLECTOR
I Broad strong bottom return, usually without sub-bottom penetration - SANDY SILT
II Weak bottom return with good sub-bottom penetration - MUD FACIES; SUBEQUAL AMOUNTS OF SILT AND CLAY
IIa Moderately strong bottom return with sub-bottom penetration - SANDY MUD
III Narrow bottom return, no penetration - SAND FACIES
SUBMERGED RIVER CHANNEL AXIS
MS26B ECHO SOUNDER PROFILES
CHALEUR BAY
BELLEDUNE TO DALHOUSIE
0 5 km

Figure 2. Sediment facies distribution based on echo-sounder surveys.

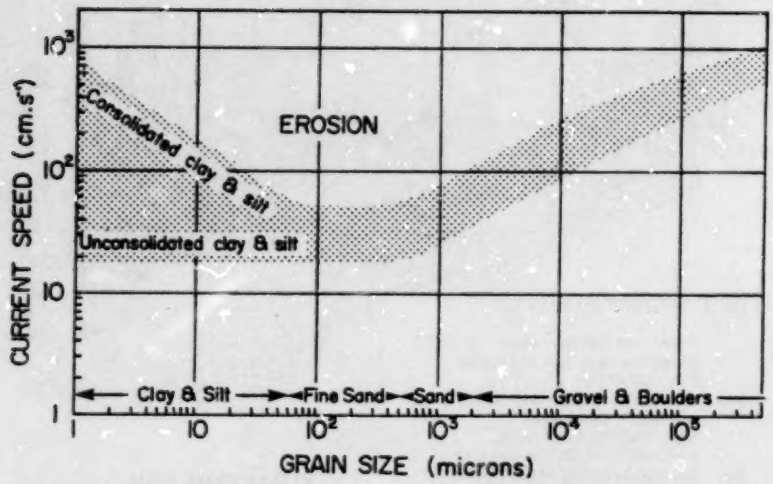

Figure 2. Shear stress diagram adapted from Hjulstrom (1935).
(Blatt et al., 1980.)

one would have to shift it some distance eastward into the type II sediment area.

The next step is to estimate the erodability of the four bottom types. While there is, of course, a great deal of uncertainty in this sort of estimate, a first approximation has been made by geologists such as Shields and Hjulstrom who measured the erosion velocities associated with different sediments over the full range of sizes from clay to coarse sand. Using Hjulstrom's well known diagram (Blatt et al., 1980) (Figure 3), and assuming, the possibility of consolidation of the silt and clay, one arrives at rough numbers for the velocity required to erode the bottom types as we have defined them.

type II:	20 to 100 cm/sec	)depending upon degree of
type II(a):	20 to 200 cm/sec	)consolidation
type I:	20 to 500 cm/sec	
type III:	about 20 cm/sec	

Sediments with some silt and clay can consolidate over a period of time while fine pure sand is the most easily eroded type.

Summary

The work was initially set up as a test case with several questions in mind. It was hoped, if possible, that a catalog of all sounder records in dumping areas would be obtained. This was not possible, due to the number of records involved and the time required to sort them. In this particular case, however, it is felt that the results showed some value in pursuing the technique. Records were available, and were easily interpreted to produce results which were reasonable in terms of past experience, and also provided some bits of new information. The technique could be applied again elsewhere, either by using historical records from the Hydrographic Service, carrying out new surveys, or a combination of the two for comparison.

The fact that useful results can be obtained from such a rough-and-ready analysis of records, collected without such analysis

in mind, suggests that it might be worthwhile to examine improvement of the technique. The biggest weakness in the process is the large step in going from sounder information to predicting the likelihood of sediment erosion; that is, between its acoustical properties and its mechanical properties. It has been necessary to go from a sounder trace to a textural or facies description and from there through some very uncertain predictions to assessment of erosion potential. It is quite likely that a much more direct link exists. The acoustic reflectivity of any sharp interface depends simply on the ratio of sound velocity in the two media. Sound velocity in a sediment is a function of its stiffness and density which are very likely to change during consolidation, and certainly will vary with water content. Some work on selecting optimum frequency and pulse length, using test sediments of known origin and properties, could produce a return signal which would be a much clearer indicator of the mechanical properties of the sediment.

In conclusion it is suggested that this technique can be used as is, either on historical records or as a field method for surveying potential dump sites and monitoring used dump sites.

References

Blatt, H., G. Middleton and R. Murray (Editors). 1980. Origins of Sedimentary rocks. Prentice-Hall Inc., New Jersey.

King, L. 1967. Use of a conventional echo-sounder and textural analyses in delineating sedimentary facies: Scotian Shelf. Can. J. Earth Sci. Vol. 4, No. 4.

3. ASSESSMENT OF SAINT JOHN HARBOUR DREDGE SPOIL DUMP SITE AT BLACK POINT

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The project was carried out by D. B. Yurick of Marine Research Associates Ltd. (Yurick, 1982).

The objectives were to (a) compare levels of contaminants (heavy metals, PCB and PAH) in organisms taken from the dump site and from nearby control areas and (b) to determine if the benthic biota at the Black Point dump site differed appreciably from the control areas.

Two stations on the dump site and two control stations were studied. One control area was about 950 m east-northeast of the spoil ground buoy, the other about 1760 m north of the buoy. Two bottom water and two sediment samples were taken at each station. In addition, biota samples were taken by divers using a $0.25m^2$ sample frame which was set at five locations within a 9-m radius. Biota and sediment to a depth of 7.5-10 cm within the framed areas were removed by air-lift suction.

Species number and biomass were somewhat lower at the dump stations than at the control ones (Table 1), particularly in relation to control station 4 where there was a well-mixed group of deposit and suspension feeders and predators. However, the total weight of organisms recovered was only 5.95 g, not including sea grapes recovered at station 4. Obviously, the individual species and total weights were too low to permit chemical analyses of the biota. The relative scarcity of biota confirms other earlier reports of a current scoured substrate with impoverished biota.

Although the biota could not be analyzed, sediment samples were analyzed for Pb, Cd, Cu, Zn, Hg, PCB (Table 2) and PAH (Table 3). Of the metals, only Cu and Zn levels were significantly higher at dump site stations than at the control stations. (ANOVA; Cu $p<0.01$, Zn $p<0.05$). The levels of PCB (Table 2) and PAH (Table 3) were not significantly different at dump and control stations.

Direct observations of the seabed by divers and the need to break sediments loose to allow sampling by air-lift suction indicate that fine unconsolidated sediment is transported from the area by bottom water currents. Presumably, the currents are a major factor in limiting the benthic biota in the Black Point area.

References

Yurick, D.B. 1982. Assessment of Saint John Harbour dump site. Marine Research Associates report to Department of Fisheries and Oceans, St. Andrews Biological Station, 24 pp.

Table 1. Species diversity (S) and organism numbers and biomass (wet weight) per m^2 at four stations near the Black Point dump site.

	Dump sites		Control Sites	
	Station 1	Station 2	Station 3	Station 4
S	6	8	9	22
Organisms/m^2	40.8[a](12.8)	18.7	32.8	216.8[b]
Biomass/m^2	0.0345 g[a]	0.574 g	1.429 g	25.94 g[b]

[a]Number biased upward, biomass downward by hydroids on a rock, not weighed. Deletion of the 35 hydroids yields 12.8 organisms /m^2 for station 1.

[b]Number and biomass biased upward by large number of sea grapes, Molgula sp. at station 4.

Table 2. Results of analyses of sediments for heavy metals and PCB (as Aroclor 1254), expressed on dry weight basis.

Site		Pb ppm	Cd ppm	Cu ppm	Zn ppm	Hg pbb	PCB pbb
Stn. 1	Replicate 1	23	1	40	115	20	51
	Replicate 2	15	1	28	100	5	76
Stn. 2	Replicate 1	30	<1	40	80	25	106
	Replicate 2	54	<1	30	110	40	712[a]
Stn. 3	Replicate 1	8	<1	15	50	5	65
	Replicate 2	13	<1	17	50	5	73
Stn. 4	Replicate 1	20	1	18	70	5	72
	Replicate 2	14	<1	25	80	15	102

[a]Extract of this sample was yellow

Table 3. Results of analyses of sediments for PAH, expressed as ppm dry weight basis.

Site		Fluoranthene	Pyrene	Benz(a) anthracene	Benz(e) pyrene
Stn. 1	Replicate 1		0.1		
	Replicate 2		0.1		
Stn. 2	Replicate 1	5.7	19		
	Replicate 2	11	3	4	2
Stn. 3	Replicate 1		0.3	0.1	
	Replicate 2	0.3	0.1	0.1	
Stn. 4	Replicate 1		0.3		
	Replicate 2	0.3	0.1		

4. BIOAVAILABILITY OF CADMIUM AND ZINC FROM LEAD AND ZINC CONCENTRATES

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Large amounts of lead and zinc ore concentrates are stored year round at the ore handling wharf of Dalhousie, N.B. for shipping overseas. The harbour bottom has been seriously contaminated over the years due to weathering of the ore piles and wind-blown concentrates being deposited in the harbour. The contamination of bottom sediment has created serious dredge disposal problems due to potential bioavailability of the trace metals to marine biota. Recently Hoff et al. (1982) reported that Cu and Pb, but not Cd or Zn, are released from mine tailings by sea water. Leaching of trace metals from ore concentrates by sea water and their bioavailability to marine organisms have not been studied. It was thus considered necessary to determine whether these metals could be leached from ore concentrates by sea water and determine their bioavailability to marine biota.

Heath Steel zinc (HZn) and Brunswick zinc (BZn) ore concentrates were made available to us by Brunswick Mining and Smelting Corporation. Harbour sediment samples were collected from the West Bay of Dalhousie Harbour. Concentrations of Cu, Zn, Cd and Pb in the two ore concentrates and in the Dalhousie Harbour sediments are given in Table 1.

Table 1. Concentration of Cu, Zn, Cd and Pb (ug/g dry) in Dalhousie sediment, Heath Steele Zn ore and Brunswick Zn ore.

Material	Cd	Zn	Cu	Pb
Dalhousie sediment	43	2,310	310	5,100
Heath Steel zinc ore	850	454,000	6,400	39,200
Brunswick zinc ore	840	536,000	3,100	26,200

Leaching studies were done with Heath Steele zinc ore mixed with St. Croix sediment to simulate field conditions and the bioavailability studies were done with both ores mixed with St. Croix sediment and with Dalhousie sediment.

4.1 Leaching Studies

Desorption of Cd and Zn from HZn by sea water (28.8 o/oo salinity) and brackish water (2.9 o/oo salinity) was studied by batch technique. For the ore alone, equilibrium was reached within 6 h; the amount of metal leached by brackish water was always higher than that leached by sea water through the 48-h period (Fig. 1). Cd and Zn leached from various ore-sediment combinations were always much lower ($p < 0.05$) than for the ore alone and both metals attained an initial peak during the time course followed by a slow decline to an equilibrium level in 48-120 h.

Amounts of Cd and Zn leached under anaerobic conditions were always lower than under aerobic conditions. Presence of organic matter in the sediment influenced desorption of both Cd and Zn. Use of H_2O_2-treated sediment instead of untreated sediment in the desorption studies increased the levels of Cd and Zn released by 1.1 to 4 and 1.2 to 2 times, respectively. The desorption of the metals in presence of H_2O_2-treated sediments also varied with salinity, largest increases being observed at lowest salinities.

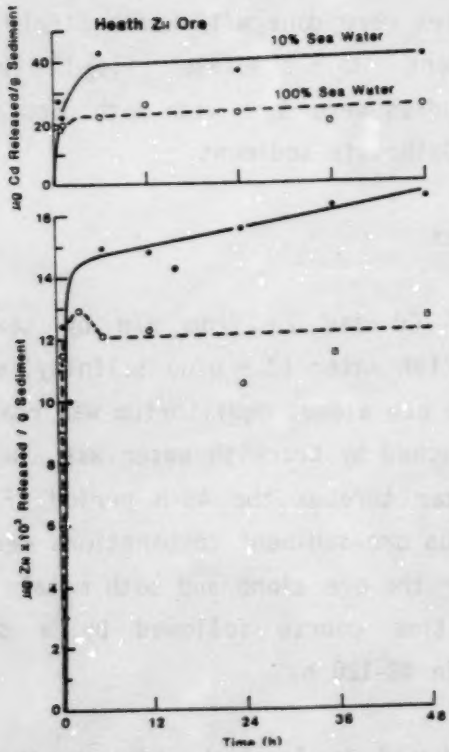

Figure 1. Time to attain equilibrium for release of Cd and Zn from Heath Steele zinc ore.

4.2 Animal Studies

Bioavailability of Cd and Zn from Heath Steele zinc ore and Brunswick zinc ore was studied in static tests at 10°C for up to 64 days. For comparison, bioavailability of the metals from Dalhousie sediment was also studied under similar conditions. Bioaccumulation of Cu and Pb was also monitored because of high Cu and Pb concentrations in the ores (Table 1) and in the leachates.

The shrimp Crangon septemspinosa and polychaete Nereis virens were used as test organisms in this study with trace metal determinations being performed on whole body samples.

Crangon septemspinosa were exposed to St. Croix estuarine sediment, to St. Croix sediment containing 1, 2 and 4%, respectively, of the two ores (HZn and BZn) and to Dalhousie sediment for a maximum period of 64 days. Nereis virens were exposed to Dalhousie sediment only. Animals exposed to 2 and 4% sediment-ore combinations survived 16-32 days and 2-4 days, respectively. Animal and water samples were collected for Cu, Zn, Cd and Pb determination.

The mean concentrations of Cu and Cd in Nereis and Crangon exposed to Dalhousie sediment did not change significantly ($P < 0.05$) from control values while Pb and Zn were significantly higher (Fig. 2-5). Similar results were obtained with Crangon exposed to the sediment-ore combinations. The Zn concentrations in Crangon exposed to the two sediments containing 1% ore and Dalhousie sediment were only 3-4 times higher than in the controls. But the Pb concentrations in animals exposed to Dalhousie sediment were 66 times higher than the controls compared with only 4 times in the animals exposed to the ores. The observed high Pb concentrations in animals exposed to Dalhousie sediment could be related to high Pb concentrations (240 ug Pb/ml) in the overlying water compared with only 21 ug Pb/ml in water overlying the two ore-sediment mixtures at the end of a 64-d exposure period.

Accumulation of Cd by the animals was not significant ($P < 0.05$) in all cases, though the overlying water contained appreciable concentrations of Cd (2-4 ng/ml). It is suggested that presence of Zn at 600-2000 times the concentration of Cd (1.25-2.5 ug Zn/ml) may have caused near total suppression of Cd accumulation. Decrease in Cd bioaccumulation in presence of Zn has been reported for a number of marine organisms (Ray et al. 1979, 1980; Jackim et al. 1977).

The bioaccumulation pattern for the trace metals in Crangon and Nereis observed in the present study parallels those reported earlier (Ray et al. 1981) with Dalhousie sediment containing much lower concentrations of the metals. The concentrations of the metals (except Pb) in the overlying water and in the animals exposed to sediment containing 1% HZn closely resembled those in Dalhousie sediment.

In conclusion, Cu, Zn, Cd and Pb are leached by sea water from the ore concentrates, but the degree of leaching is lowered by the presence of sediment, organic matter and increase in salinity. Pb and Zn were bioavailable under the test conditions. However, it would not be appropriate to extrapolate the results obtained in these laboratory tests to the dynamic situation prevailing at Dalhousie harbour.

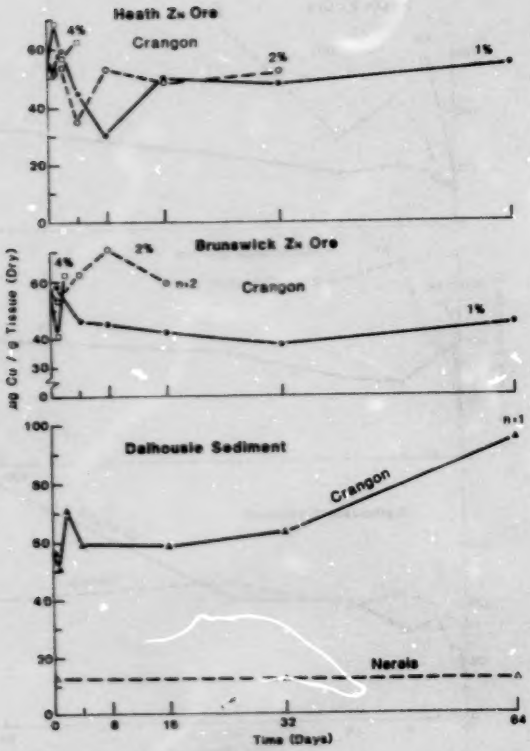

Figure 2. Mean Cu concentrations in Crangon and Nereis exposed to Dalhousie sediment and to St. Croix sediment containing 1, 2, and 4%, respectively, of the two ores (Heath Zn ore and Brunswick Zn ore). Each point represents mean of 4 analyses unless stated otherwise.

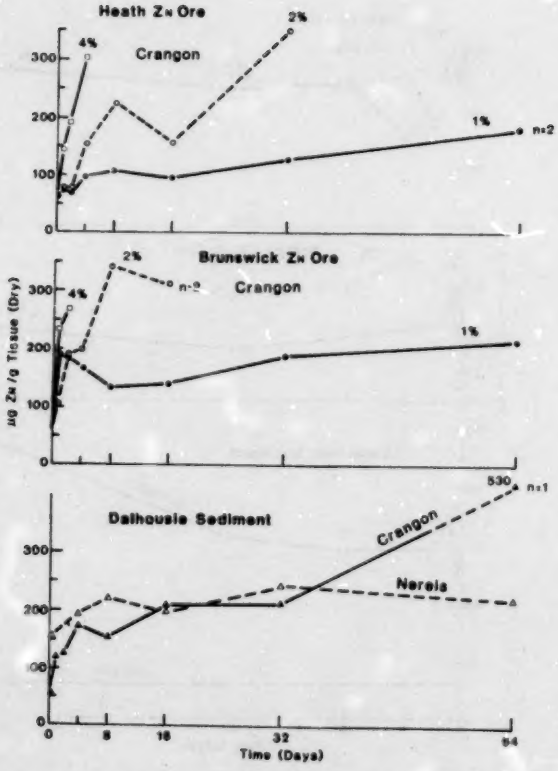

Figure 3. Mean Zn concentrations in Crangon and Nereis exposed to Dalhousie sediment and to St. Croix sediment containing 1, 2, and 4%, respectively, of the two ores (Heath Zn ore and Brunswick Zn ore). Each point represents mean of 4 analyses unless stated otherwise.

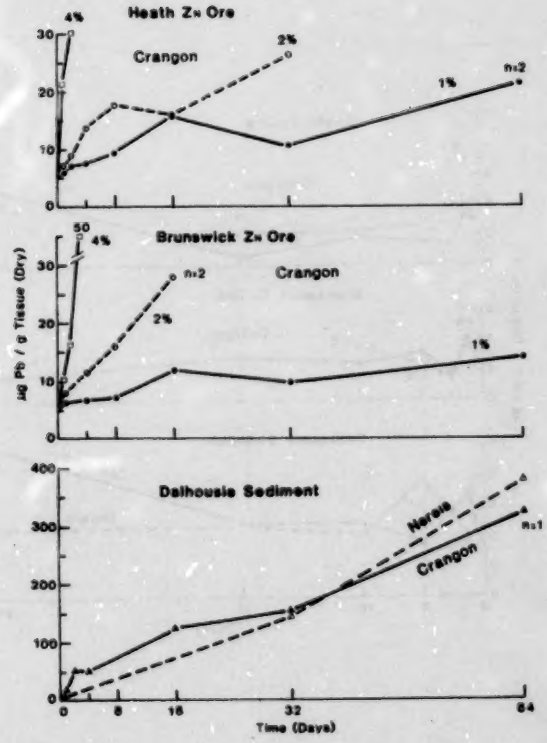

Figure 4. Mean Pb concentrations in Crangon and Nereis exposed to Dalhousie sediment and to St. Croix sediment containing 1, 2, and 4%, respectively, of the two ores (Heath Zn ore and Brunswick Zn ore). Each point represents mean of 4 analyses unless stated otherwise.

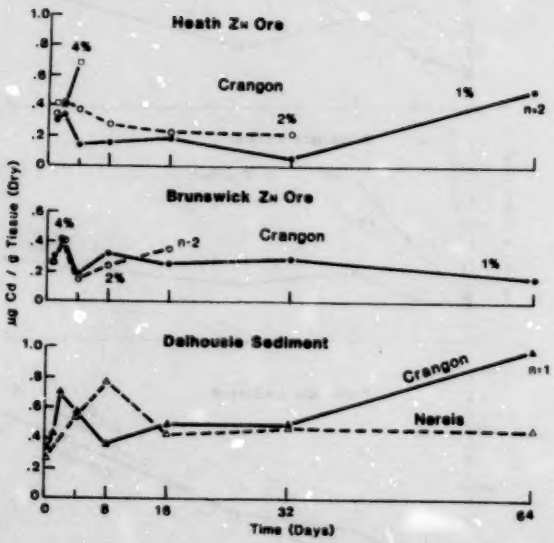

Figure 5. Mean Cd concentrations in Crangon and Nereis exposed to Dalhousie sediment and to St. Croix sediment containing 1, 2, and 4%, respectively, of the two ores (Heath Zn ore and Brunswick Zn ore). Each point represents mean of 4 analyses unless stated otherwise.

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5. FIELD INVESTIGATION INTO THE DIRECT AND INDIRECT EFFECTS OF OCEAN DUMPING ON LOBSTER ECOLOGY AND HABITAT (STATUS REPORT II)

by

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5.1 Introduction

The American lobster, Homarus americanus, inhabits a wide range of substrate types, but is most common, in inshore waters, on sand with overlying rocks and boulders (Cooper and Uzmann, 1977). Juvenile lobsters can dig tunnels in firm clay/mud (Cobb, 1977). In the laboratory, early stage juvenile lobsters show a clear preference for gravel substrate compared to silt-clay deposit over gravel (Pottle and Elner, 1982). Dumping of dredge spoils may profoundly alter lobster habitat and have direct and indirect effects on lobster mortality and productivity (Pottle and Elner, 1982).

In the present investigation, silt-clay sediment was dumped onto a presurveyed juvenile lobster 'nursery' area in Halifax Harbour in March, 1982. SCUBA divers have been monitoring the impact of the dump on the lobsters as well as on other macrofauna and-flora over a 12-month period.

5.2 Materials and Methods

The experimental site and control site are in Ferguson's Cove on the western shore of the approach to Halifax Harbour (44°37'N, 63°33W. Fig. 1). The two sites are approximately 300 m apart and

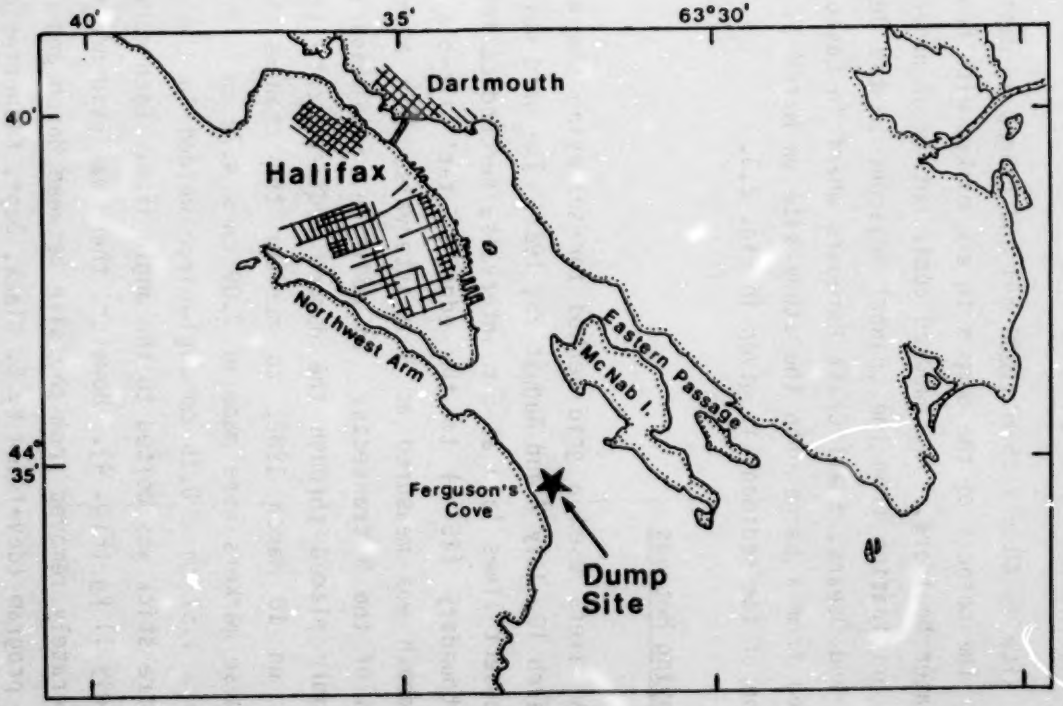

Fig. 1. Location of the experimental dump site.

were selected to provide similar physical and biological characteristics while minimizing the risk of inter-site transportation of dump materials. The substrate of the two sites is of rock-boulders on a sand-mud base.

Each site is 40 m x 25 m (1000 m^2) and ranges in depth between 5 and 12 m. The corners of the dump site are marked with buoys attached to underwater boulders. Two hundred cubic metres of non-contaminated sediment, originating from the channel adjacent to the Department of Fisheries and Oceans, Small Craft Harbours wharf in Eastern Passage, were dumped from a barge onto the study site on March 3, 1982. The composition of the sediment is given in Fig. 2,3.

5.3 Surveying Methods

SCUBA divers used a grid method for surveying the experimental site on March 10, July 7 and August 25, 1982. The grid was made up of bottom transect lines laid at 5 m intervals, perpendicularly from the southern boundary (25 m) to the edge of the silt-clay sediment. Sediment depth was measured at 5 m intervals, with a metre stick, along each of the 5 transects. In addition, ten measuring markers were randomly placed through the dumped sediment onto the original substrate, on 10 March 1982, to monitor the changes in sediment depth. These markers were made of 7.09 cm x 4.72 cm x 0.15 cm iron plate with a 1.57 cm x 0.15 cm angle iron welded in the middle. A plastic metre stick was bolted to the angle iron. Each marker weighed approximately 11 kg (Fig. 4). However, there was evidence the markers were deliberately removed from the site between March and July, 1982. A computer program (developed by G. Black, Dept. Fisheries and Oceans, Marine Fish Section, St. Andrews, N.B.) was used to illustrate the changes in the topography of the dump site over time (Fig. 5-7) from the transect data.

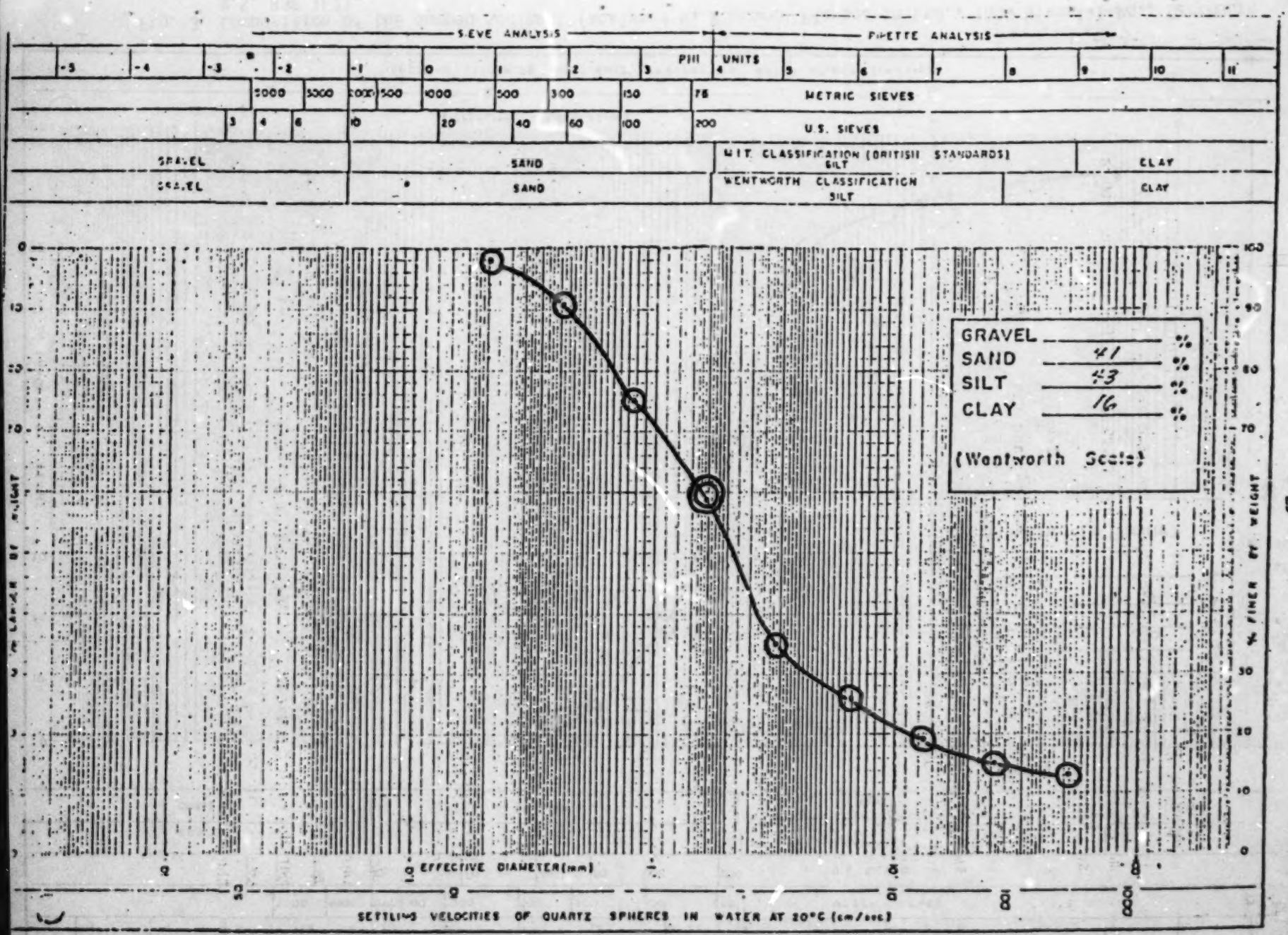

Fig. 2. Composition of the dumped sediment (analysed by MacLaren Plansearch Ltd., 1000 Windmill Rd., Dartmouth N.S. B3B 1L7).

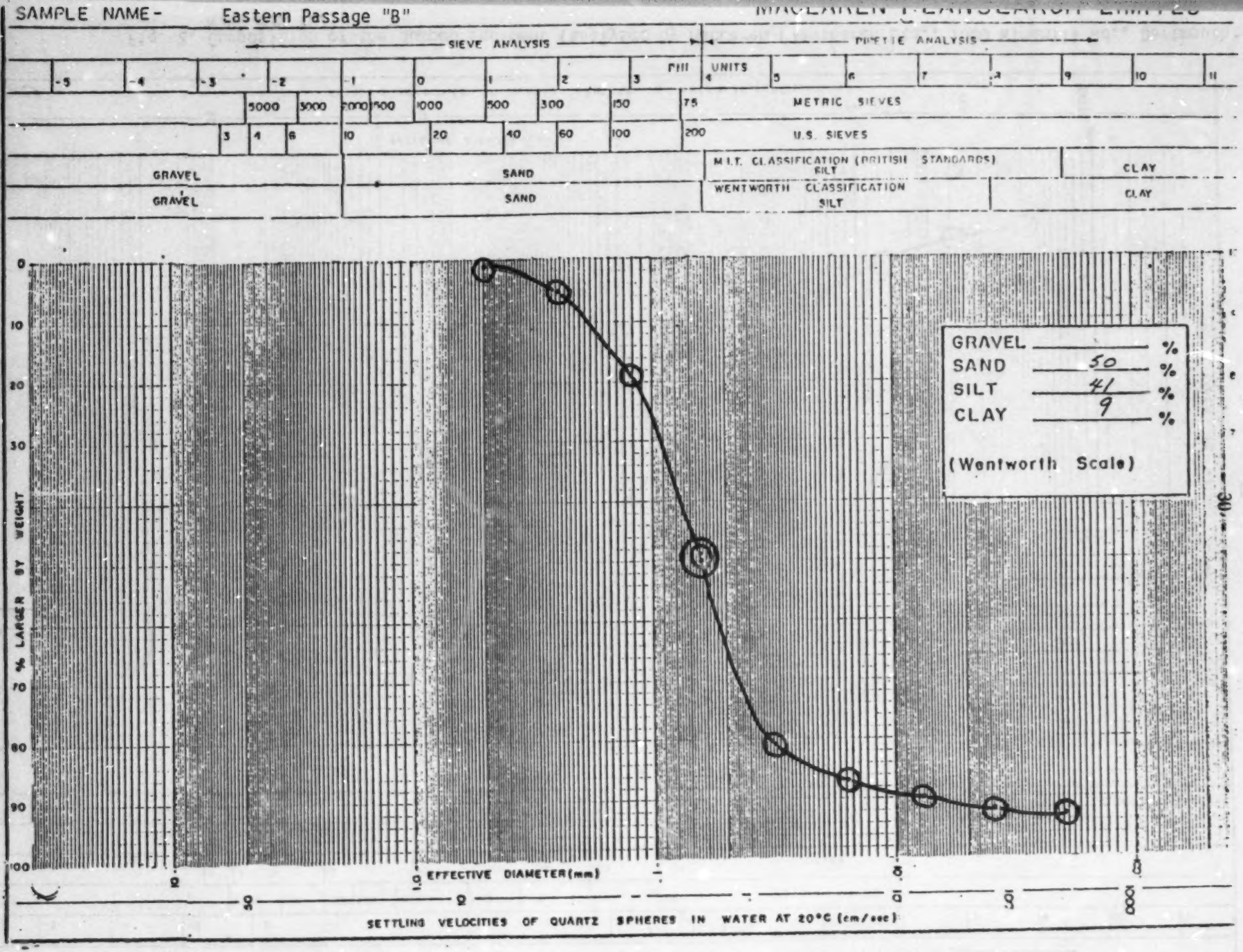

Fig. 3. Composition of the dumped sediment (analysed by MacLaren Plansearch Ltd., 1000 Windmill Rd., Dartmouth N.S. B3B 1L7).

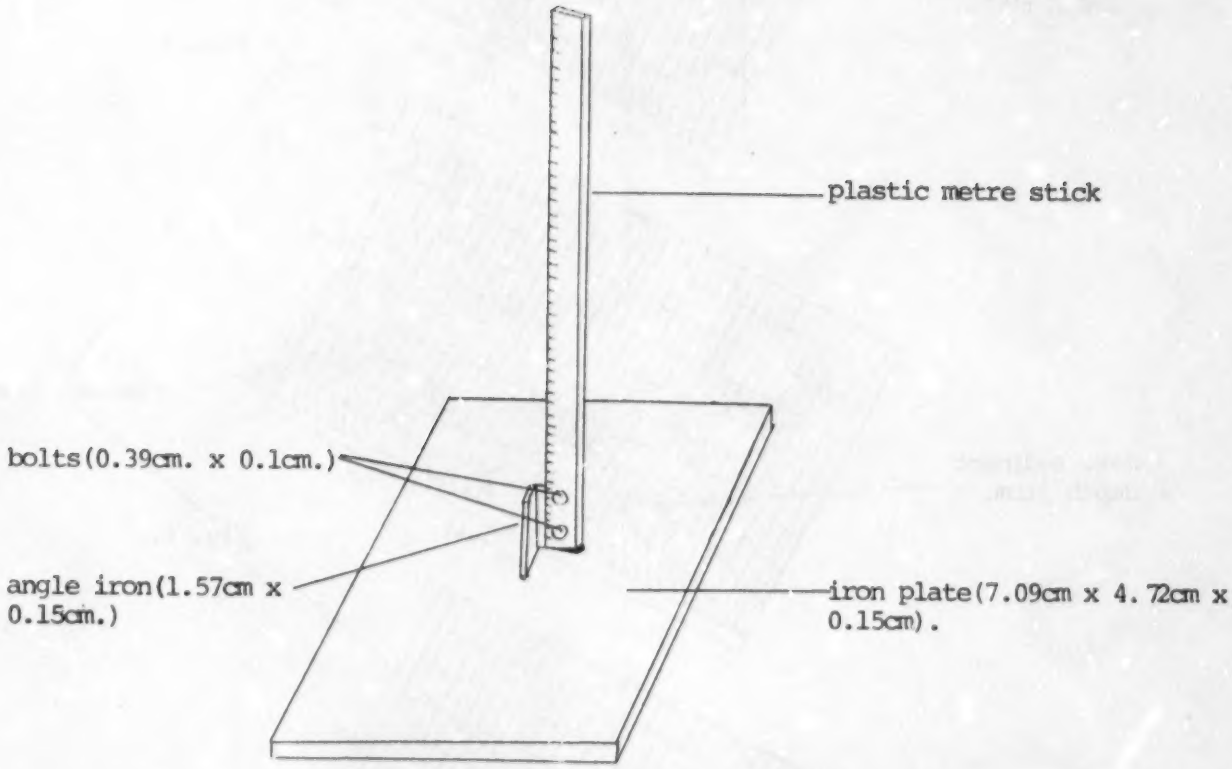

Fig. 4. Measuring marker (not to scale). Approximate weight-11 kg.

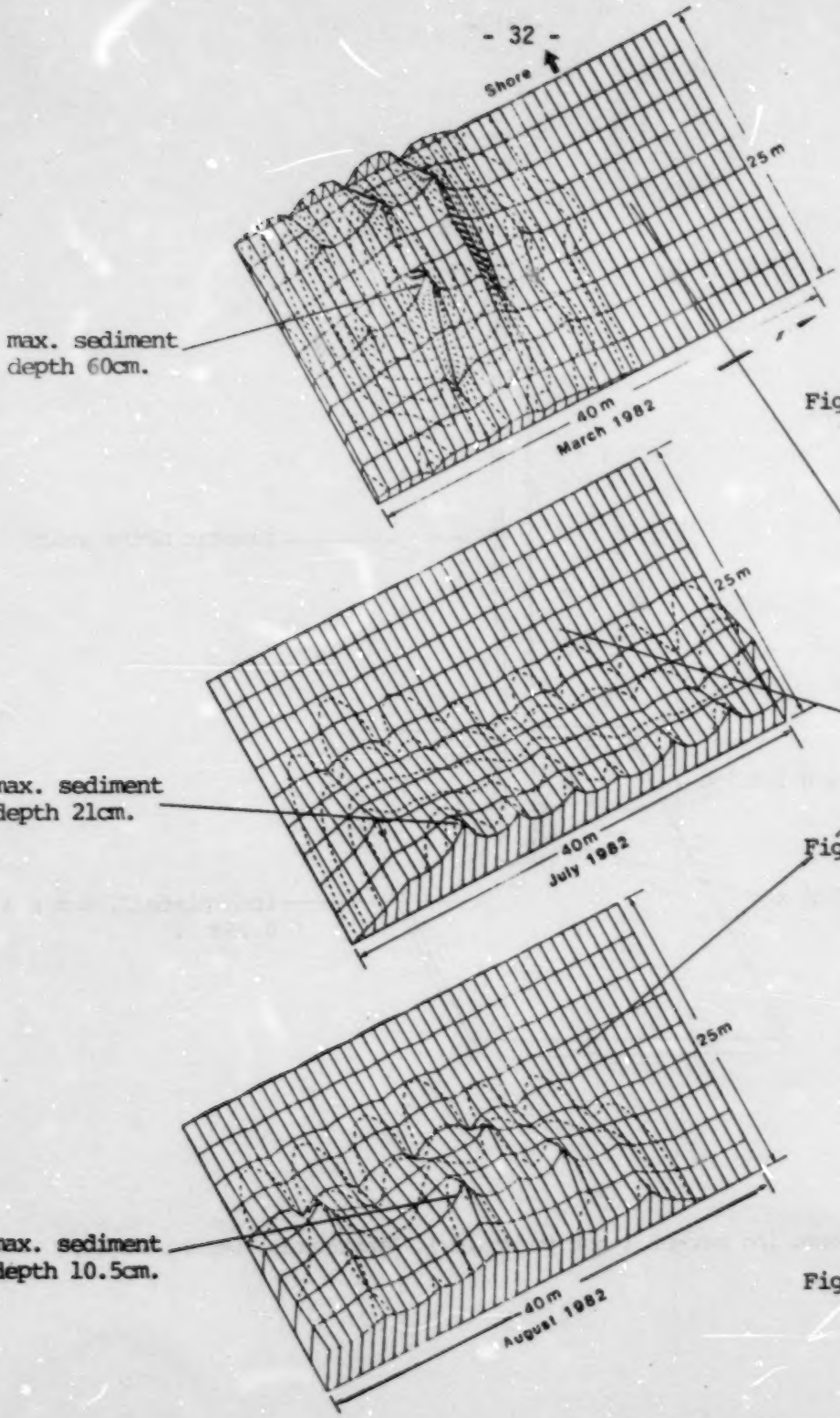

Fig. 5-7. Profiles of the experimental site covered with dumped sediment over time. Scale: 4.8cm = 25m.

5.4 Population Sampling

Population surveys on the experimental and control sites were conducted on Febrary 3, March 10-11, July 7, and August 25, 1982. A 5 m transect line was randomly placed on the bottom. A pair of divers sampled 1 m on both sides of the line. Captured lobsters and crabs were brought to a boat on the surface for carapace length or width measurement and species identification. Sex, shell hardness and egg conditions were also noted. Animals were released back onto the site immediately after the recordings. Lobsters and crabs located in each sampling area but not captured were also included in the estimates of density. A total of sixty-one transects were sampled at the two sites. In addition, common macrofauna and-flora present in each site were noted by divers swimming slowly over the whole area.

5.5 Results and Discussion

The amount of sediment dumped (200 m^3) in this experiment is relatively small compared to a full scale dredging operation (e.g. Dalhousie, N.B. over 5 years the total quantity dredged spoil was 280,021 m^3. MacKnight, 1982). The area covered by dumped sediment within the experimental site was 400 m^2 in March, 360 m^2 in July and 270 m^2 in August (Fig. 5-7). The maximum sediment depth decreased from 60 cm in March to 21 cm in July and 10.5 cm in August. In addition, the characteristics of the sediment inside the dump site changed: in July and August a thin layer of fine brownish material was found on top of the gray coloured silt-clay originally dumped. The fine material was also deposited on algae and rocks in shallow areas devoid of any dump sediment.

The macrofauna and -flora present during the four sampling periods is given in Table 1. The diversity of animals and algae were considerably reduced in areas covered with dumped sediment. Species that vanished included those frequent in the diet of lobsters and crabs (Scarratt and Lowe, 1972; Elner, 1981; Drummond-Davis et al. 1982). Dead pelecypoda with intact shells were found littered on the sediment in the March to August surveys.

Table 1. Macroflora and -fauna present in the dump site and control site at Ferguson's Cove (I=Feb., 82; II=March, 82; III=July, 82; IV=Aug., 82)

Species	Experimental Site		Control Site
	Rocky Bottom	Silt-clay Bottom	Rocky Bottom
Algae			
Agarum	III,IV		III,IV
Corallina	III,IV		III,IV
Fucus	I,II,III,IV		I,II,III,IV
Ulva	III,IV		III,IV
Laminaria	III,IV		III,IV
Desmerestia	III,IV		III,IV
Anthoza			
M. senile	I,II,III,IV	II,III,IV	I,II,III,IV
Amphineura			
I. ruber	I,II,III,IV		I,II,III,IV
Gastropoda			
A. testudinalis	I,II,III,IV		I,II,III,IV
L. littorea	I,II,III,IV		I,II,III,IV
B. undatum	I,II,III,IV	II,III,IV	III,IV
C. fornicata	I,II,III,IV		I,II,III,IV
Pelecypoda			
M. modiolus	I,II,III,IV		I,II,III,IV
A. aculeata	I,II,III,IV		I,II,III,IV
H. arctica	I,II,III,IV		I,II,III,IV
Polychaeta			
L. squamatus	I,II,III,IV		I,II,III,IV
Nereis sp.	II,III,IV		I,II,III,IV
Crustacea			
B. balanoides	II,III,IV		II,III,IV
H. americanus	I, IV	II	I,II,III,IV
Parqurus sp.	I,II,III,IV	II,III,IV	II,III,IV
C. irroratus	II,III,IV	III,IV	II,III,IV
C. borealis	III,IV	II,III	III
C. maenas	III		IV
Echinoidea			
S. droebachiensis	I,II,III,IV		I,II,III,IV
Stellerodea			
A. vulgaris	I,II,III,IV	II,III,IV	I,II,III,IV
O. aculeata	I, III,IV	II,III,IV	III,IV
H. sanguinolentea			I
Selachii			
Raja sp.		III	
Pisces			
M. americanus	I		
O. lupus	IV		
P. americanus		II,III,IV	

The mean size and range of lobsters and three crab species sampled in the two sites over time are shown in Table 2-5. There were no statistical differences (t-test, $P > 0.05$) between the mean sizes of lobsters from the two sites in either the pre-dump survey, or the subsequent two sampling periods. However, the mean lobster size from the experimental site in August was significantly larger ($P < 0.01$) than any period. The mean size of rock crabs showed no differences ($P > 0.05$) between sites and over time. Statistical analyses were not applied to jonah crab or green crab samples because of the small sample sizes. The overall male:female ratios were 0.49:1 for lobsters and 1:0.56 and 1:0.4 for rock and jonah crabs, respectively.

The density (No./m^2) of lobsters in the experimental site was 0.24/m^2 prior to the dump. However, density was reduced to 0 in the March and July surveys, and 0.08/m^2 in August, for the rock-boulder substrate of the experimental site (Table 6). In the silt-clay, the density was 0.03/m^2 in March and 0 in July and August (Table 6). The density of lobster inside the experimental site was lower than the control site (0.07-0.25/m^2) and other similar substrate types reported by Cobb (1971), Scarratt (1973), Cooper et al. (1975), Cooper and Uzmann (1977) along the northwestern Atlantic coast (Table 7). The low density of lobster in the area covered with dumped sediment was most probably due to the lack of suitable shelter. Suitable shelter necessitates the presence of embedded stones, overlying rocks, gravel or other solid objects for lobsters to use as 'hides' or as supporting structures for their tunnels (Berrill and Stewart, 1973; Cooper and Uzmann, 1977; Pottle and Elner, 1982). The density of lobsters in mud substrate without such supporting structures tends to be relatively low (Cooper and Uzmann, 1977). In addition, mud must be firm enough so that excavations do not collapse (Berrill and Stewart, 1972). Although there were probably suitable shelters in the rock-boulder part of the experimental site, the low density of lobsters found indicates that the dump not only affected the actual dump area but also influenced the surrounding zone over several months.

Table 2. Size-frequency distribution of H. americanus sampled in Ferguson's Cove over time (animals located but not measured are not included).

	Experimental Site								Control Site			
	Rocky Bottom				Silt-clay Bottom				Rocky Bottom			
Period	N	$\bar{X}$(mm)	±1 SE	Range	N	$\bar{X}$(mm)	±1 SE	Range	N	$\bar{X}$(mm)	±1 SE	Range
I	30	39.07	2.33	20-66	-	-	-	-	7	37.43	3.04	26-50
II	Ø	-	-	-	1	43	-	43	8	45.5	4.59	28-65
III	Ø	-	-	-	Ø	-	-	-	8	48.75	7.33	26-89
IV	3	89.33	26.08	42-132	Ø	-	-	-	2	63.5	1.5	62-65

Table 3. Size frequency distribution of C. irroratus sampled in Ferguson's Cove over time (animals located but not measured are not included).

	Experimental Site								Control Site			
	Rocky Bottom				Silt-clay Bottom				Rocky Bottom			
Period	N	$\bar{X}$(mm)	±1 SE	Range	N	$\bar{X}$(mm)	±1 SE	Range	N	$\bar{X}$(mm)	±1 SE	Range
I	-	-	-	-	-	-	-	-	-	-	-	-
II	4	47.75	8.11	26-65	Ø	-	-	-	4	51.25	3.75	44-61
III	6	65.83	6.32	36-78	2	22.0	3.0	19-25	4	55.25	7.49	33-65
IV	11	67.27	6.53	33-99	1	76.0	-	76	10	66.0	3.56	49-83

Table 4. Size-frequency distribution of C. borealis sampled in Ferguson's Cove over time (animals located but not measured are not included).

	Experimental Site								Control Site			
	Rocky Bottom				Silt-clay Bottom				Rocky Bottom			
Period	N	$\bar{X}$(mm)	±1 SE	Range	N	$\bar{X}$(mm)	±1 SE	Range	N	$\bar{X}$(mm)	±1 SE	Range
I	-	-	-	-	-	-	-	-	-	-	-	-
II	Ø	-	-	-	1	81	-	81	Ø	-	-	-
III	8	42.5	9.62	18-106	1	15	-	15	4	66.5	5.8	51-79
IV	1	107	-	107	Ø	-	-	-	Ø	-	-	-

Table 5. Size frequency distribution of C. maenas sampled in Ferguson's Cove over time (animals located but not measured are not included).

	Experimental Site								Control Site			
	Rocky Bottom				Silt-clay Bottom				Rocky Bottom			
Period	N	$\bar{X}$(mm)	±1 SE	Range	N	$\bar{X}$(mm)	±1 SE	Range	N	$\bar{X}$(mm)	±1 SE	Range
I	-	-	-	-	-	-	-	-	-	-	-	-
II	Ø	-	-	-	Ø	-	-	-	Ø	-	-	-
III	1	37.0	-	37.0	Ø	-	-	-	Ø	-	-	-
IV	Ø	-	-	-	Ø	-	-	-	2	49.0	12.0	37-61

Period I = February, before dumping.
II = March, 1 week after dumping.
III = July, 17 weeks after dumping.
IV = August, 24 weeks after dumping.

Table 6. Density, No./m^2 of lobster and crab species sampled at the dump and control sites in Ferguson's Cove over time. ( ) = number of lobsters.

	Experimental Site						Control Site		
	Rocky Bottom			Silt-clay Bottom			Rocky Bottom		
Period	H. americanus	C. irroratus	C. borealis	H. americanus	C. irroratus	C. borealis	H. americanus	C. irroratus	C. borealis
I	0.24(31)	0.25 (not differentiated into sp.		-	-	-	0.07(7)	1.60 (not differentiated into sp.	
II	0	0.13	0	0.03(1)	0	0.03	0.13(8)	0.07	0
III	0	0.3	0.4	0	0.04	0.02	0.18(9)	0.08	0.08
IV	0.08(4)	0.22	0.02	0	0.03	0	0.08(3)	0.25	0

Period I = February, before dumping.
II = March, 1 week after dumping.
III = July, 17 weeks after dumping.
IV = August, 24 weeks after dumping.

Table 7. Estimates of density (No./m^2) on H. americanus in various inshore areas along the N.W. Atlantic Coast.

Time	Area	Type of Bottom	Sampling Method	No./m^2	Mean C.L.(mm)	Source
May-Aug.	P.E.I.	Flat bedrock - boulder-rock substrate	Scuba	0.007-0.11	39.73	Scarratt (1973)
Monthly Average	Gulf of Maine	Sandy substrate - overlying flattened rocks	"	1.2	>40.0	Cooper et al (1975); Cooper and Uzmann (1977)
July	Rhode Is.	Mud-shell/rock	"	0.15	-	Cobb (1971)
March	Ferguson's Cove, N.S.	Sediment	"	0.03	43.0	Present Study
Feb.-Aug.	Ferguson's Cove	Rock-boulder (Dump site)	"	0.08-0.24	44.07	Present Study

Table 8. Estimates of Density (No./m^2) on C. irroratus in various inshore areas along the Canadian Maritimes coast.

Time	Area	Type of Bottom	Sampling Method	No./m^2	Mean C.W.(mm)	Source
Spring	Northumberland Strait	Sand	Scuba	0.02	84.1	Scarratt & Lowe (1972)
"	" "	Boulders	"	0.04	72.3	" " "
"	" "	Bedrock	"	0.02	65.3	" " "
Fall	" "	Sand	"	0.003	112.0	" " "
"	" "	Boulders	"	0.11	49.0	" " "
"	" "	Bedrock	"	0.05	57.0	" " "
July-Sept.	Callahan Is., N.S.	Kelp bed	Traps	0.5	>45	Drummond-Davis, et al. (1982)
July-Aug.	Ferguson's Cove, N.S.	Sediment	Scuba	0.03-0.04	49.0	Present Study
March-Aug.	" "	Rock (Dump Site)	"	0.13-0.3	63.14	" "

Scarratt and Lowe (1972) reported rock crabs less than 65 mm carapace width inhabiting rocky areas, and this agrees with the size of crabs sampled in the rocky areas of our two sites (Table 3). The density of rock crabs sampled in the rock-boulder substrate of the experimental site was higher than that found in the control site and a Northumberland Strait survey by Scarratt and Lowe (1972), but less than an estimated crab density in a kelp bed off Callahan Island, Nova Scotia (Drummond-Davis et al. 1982) (Table 8). The highest density of jonah crabs was in the rock-boulder part of the experimental site on the July survey (Table 6).

As a result of the dump, a shortage of principal food types (polychaetes, gastropods, hermit-crabs, bivalves, sea urchins) and the loss of suitable shelter for lobsters and crabs could increase competition for the remaining resources. Such competition between species could: 1) increase lobster mortality, 2) decrease growth (Cooper and Uzmann, 1977; Cobb and Tamm, 1974) and 3) increase movement away from the affected areas (Cooper and Uzmann, 1977). Possible effects on the surrounding areas would be from: 1) increasing competition on resources, and 2) shifting of the dump sediment. Further surveys are planned to monitor the sites until April, 1983.

Acknowledgments

We thank: the R.W. Welsford Research Group Ltd. for site selection, performing the experimental dumping and the pre-dump surveys; M. Batten, L. V. Colpitts, M. Etter, C. MacTavish and D.A. Robichaud for diving assistance. Principal research funding was provided by RODAC.

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6. ANALYSIS OF STOMACH CONTENTS OF SMELT FROM THE MIRAMICHI ESTUARY

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ABSTRACT

During the winter of 1981-82 the stomach contents of 535 smelt, captured in commercial fishing gear, were analysed and compared with 104 smelt analysed in 1979. Significant differences were found in several parameters examined. Smelt prey on a wide range of benthic and planktonic invertebrates and fish, including smaller smelt. There were some differences in the species identified in the two years, but principal differences relate to the higher frequency of empty stomachs, the lower number of prey items in each stomach, and the lower fullness index in 1982. There appeared to be a shift away from benthic toward planktonic species.

Interpretation is incomplete. It is uncertain whether these shifts represent a depletion of food resources and a move towards utilization of available rather than preferred food, or whether it represents an acceleration of the non-feeding period prior to maturation and spawning. It is possible that the changes are the result of increased sedimentation generally across Miramichi Bay.

7. ANALYSIS OF AVOIDANCE BEHAVIOUR OF SMELT IN MIRAMICHI DREDGE SPOIL PLUMES

by

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The possibility that commercially important species of fish such as herring, gaspereau and smelt may avoid areas where high levels of suspended sediments are present, has prompted laboratory behaviour experiments to test this. In earlier work using the "schooling fish bioassay" it has been shown that herring avoided pulp mill effluent (Wildish et al. 1977) and dredge spoils (Johnston and Wildish, 1981). Recently Mathur et al. (1982) and Mathur and Silver (1980) have questioned the independence of data points in behavioural experiments of this kind, particularly, repeated observations on the same group of fish. Behaviourally it is believed (Johnston and Wildish, 1981) that fish undergo a learning process during exposure to suspended sediments, which is the conditioning stimulus, thus supporting the view that the temporal observations are not independent, and consequently analysis of variance is an inappropriate test.

Because of these difficulties a new test has been devised and preliminary data are presented, with smelt as the subject and suspended sediment as the conditioning stimulus.

7.1 Materials and methods

Sediment was obtained from buoy #5 in the Miramichi estuary. The apparatus was as used previously (Johnston and Wildish 1981), and consisted of a figure-of-eight maze with a common wall and a 10 x 10 cm aperture connecting the two halves of the maze. Each half of the

maze was supplied with a separate water flow of 7L/min from a common source of temperature-regulated seawater. Smelt were obtained by trawling in Passamaquoddy Bay and acclimated in large holding tanks until they were feeding satisfactorily on brine shrimp.

7.1.1 "Individual Fish Bioassay"

An individual smelt was placed in the arena and after 30 min was timed until it made 10, 20 or more traverses of the 10 x 10 cm aperture. This is the control period and arbitrarily sets the time of the dosing period following addition of sediment and after a 1 min delay to allow the concentration to build-up. Observations are continued for a time period equal to that of the control. Time in side A and B is recorded as well as the number of aperture traverses made by the fish. The side on which the suspended sediment is added is decided by reference to a table of random numbers. The test statistic is then the time spent in the control compared to the test side of the apparatus. This comparison is made on at least 10 fish separately by t-test with 9 degrees of freedom.

7.2 Results

Typical results (Table 1) of an experiment show individual differences in response perhaps associated with individual differences in locomotory activity, motivation or learning speed.

Table 1. Time (min) spent in side B of the maze by smelt at 10°C. Addition of 22 mg/l suspended sediment during the test period.

Fish #	1	2	3	4	5	6	7	8	9	10
Control	9.60	6.57	10.84	3.03	3.00	6.08	8.36	3.20	4.03	12.80
Test	3.61	4.71	3.13	2.39	3.25	4.43	8.76	2.40	4.56	7.45

The results obtained so far with this technique are shown in Table 2, and suggest a threshold between 17-22 mg/l.

Table 2. Individual smelt behaviour experimental results for 10 traverses of the aperture.

Temp °C	Suspended sediment mg/l	side	Significance	Aperature Control	Traverses Test
10	17.5	B	N.D.	100	79
7	22.0	B	**	100	82
10	23.5	A	**	100	63

It is emphasized that if the period of observation is increased, e.g. by using 20 traverses of the aperture, so will the results change. The fewer traverses made during the test period does not necessarily indicate a reduction in the locomotory activity but is linked to the learning process. Possibly increased swimming activity occurs in the untreated side of the maze, although this was not measured during the test. It is clear from this that aperture traverses and time spent in the treated side of the maze are linked responses, if learning is involved, and only one of them is admissable for statistical analysis.

7.3 Discussion

Further development of this behavioural assay is underway; particular attention will be paid to the effect of time on response, possible effect of conditioning stimulii such as visual references and the effect of temperature on level of activity.

A close similarity exists between the two types of test which involve a dose-time effect response. Like lethal tests caution is advised in extrapolating from these apparatus specific tests to the field where the real world multiplicity of variables will confound most attempts at predictions.

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Mathur, D., Schutsky, R.M. and E.J. Purdy. 1982. Temperature preference and avoidance responses of the crayfish, Orconectes obscurus, and associated statistical problems. Can. J. Fish. Aquat. Sci. 39: 548-553.

Mathur, D. and C.A. Silver. 1980. Statistical problems in studies of temperature preference of fishes. Can. J. Fish. Aquat. Sci. 37: 733-737.

Wildish, D.J., Akagi, H. and N.J. Poole. 1977. Avoidance by herring of dissolved components in pulp mill effluents. Bull. Environ. Contam. Toxicol. 18: 521-525.

8. WINTER WATER QUALITY STUDIES IN THE MIRAMICHI RIVER ESTUARY

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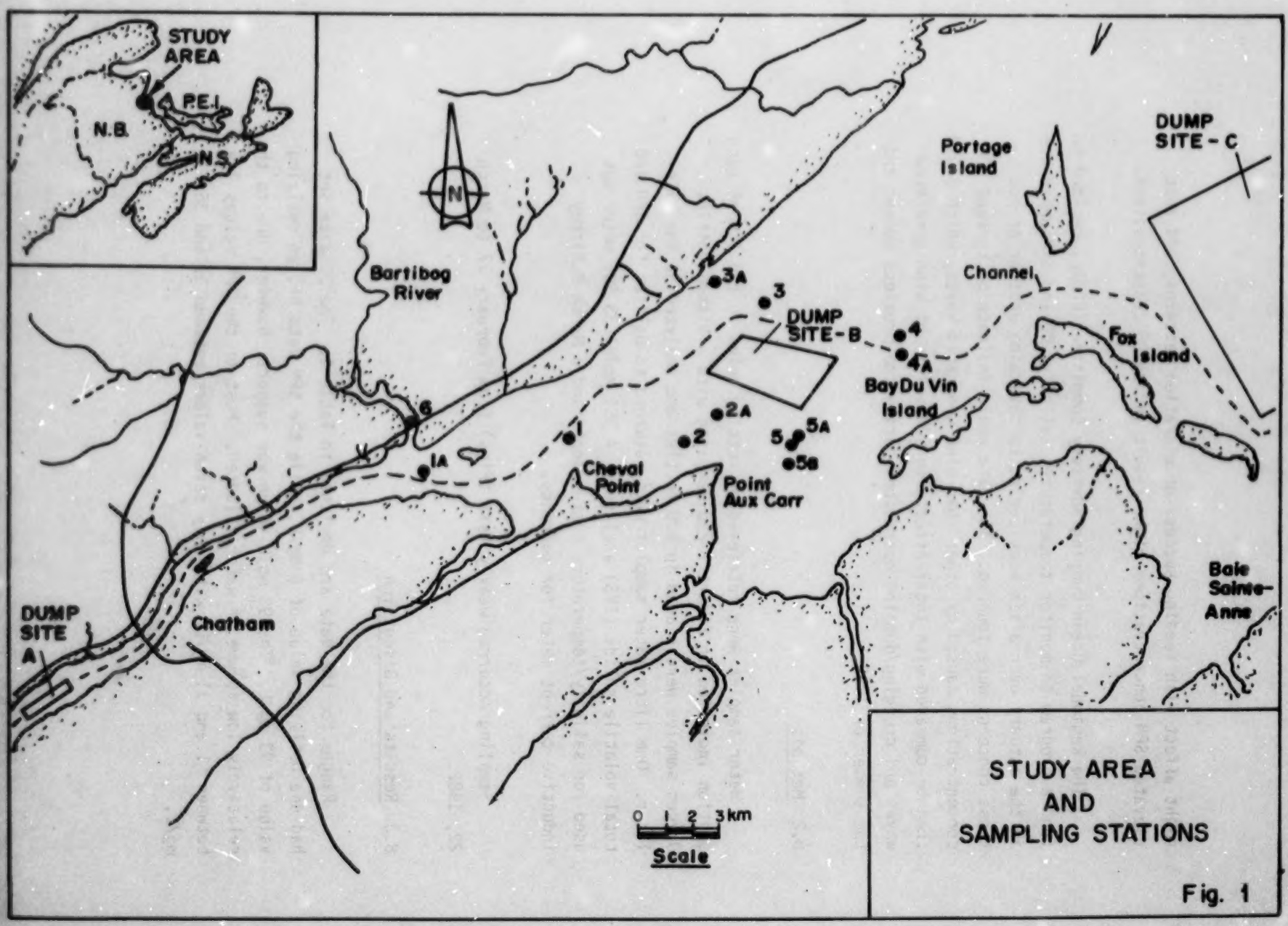
Halifax, N.S.
**Environmental Protection Service
Dartmouth, N.S.

8.1 Introduction

In 1981, the Miramichi Channel Dredging Project dredged and dumped in the order of three million cubic metres of material along a 58 km channel in the Miramichi River estuary. Dumping occurred at dump sites A, B and C as depicted in Figure 1. The dredging project as originally planned, was to extend over two dredging seasons with operational dumping to take place at dump site C, and test dumping at Sites A and B, in the first year. The behaviour (stability) of material dumped under test conditions at sites A and B was to be studied through the first dredging season and following winter, and then decisions to permit dumping on sites A and B were to be made based on the results of those studies. In fact, Public Works Canada reduced the major part of the dredging project to a one year time span by utilizing three trailing suction hopper dredges with test dumping on sites A and B carried out very early in the dredging season. The results of test dumping proved inconclusive with regard to dump site stability, so an operational water quality program was instituted which was carried out at regular intervals through the dredging season to ensure adequate protection for the aquatic environment.

While indications from the 1981 operational water quality program were that the aquatic environment and fishery resources had not been subjected to critically elevated, suspended particulate matter (SPM) concentrations or critically reduced dissolved oxygen (DO) concentrations, concerns remained as to the levels of SPM and DO under the ice during winter. There were concerns that turbidity plumes



STUDY AREA
AND
SAMPLING STATIONS

Fig. 1

might affect fish feeding success or migration patterns, and that elevated SPM concentrations might result in low DO concentrations.

The Regional Ocean Dumping Advisory Committee (RODAC) decided to fund a program to monitor temperature, salinity, DO and SPM under ice in the estuary over a six week period to determine whether or not these concerns were founded. The data would indicate background SPM concentrations caused by other than wind generated waves, which could then be compared with total effects on SPM levels of wind generated waves and dredging/dumping operations during the previous summer and the summer of 1982.

8.2 Methods

Water samples were retrieved by cutting holes in the ice at each station indicated in Figure 1 and sampling with a Nisken bottle. Oxygen samples were placed in BOD bottles and analyzed at the site later. One litre water samples were returned to Halifax for SPM and total volatile solids (TVS) analyses. A YSI Model 33 SCT meter was used for salinity/temperature measurements and a Marsh McBirney inductive current meter for currents.

Sampling occurred weekly (six trips) from February 17 to March 22, 1982.

8.3 Results and Discussion

Ranges for the data are depicted in Table 1. The DO data set had one outlying value of 6 mg/L, while the SPM data had an outlying value of 93 mg/L. The 93 mg/L value was suspect, however, due to the relatively low volume of water filtered. Most of the SPM values lay between <1 and 11 mg/L, with only seven values between 11 and 36 mg/L.

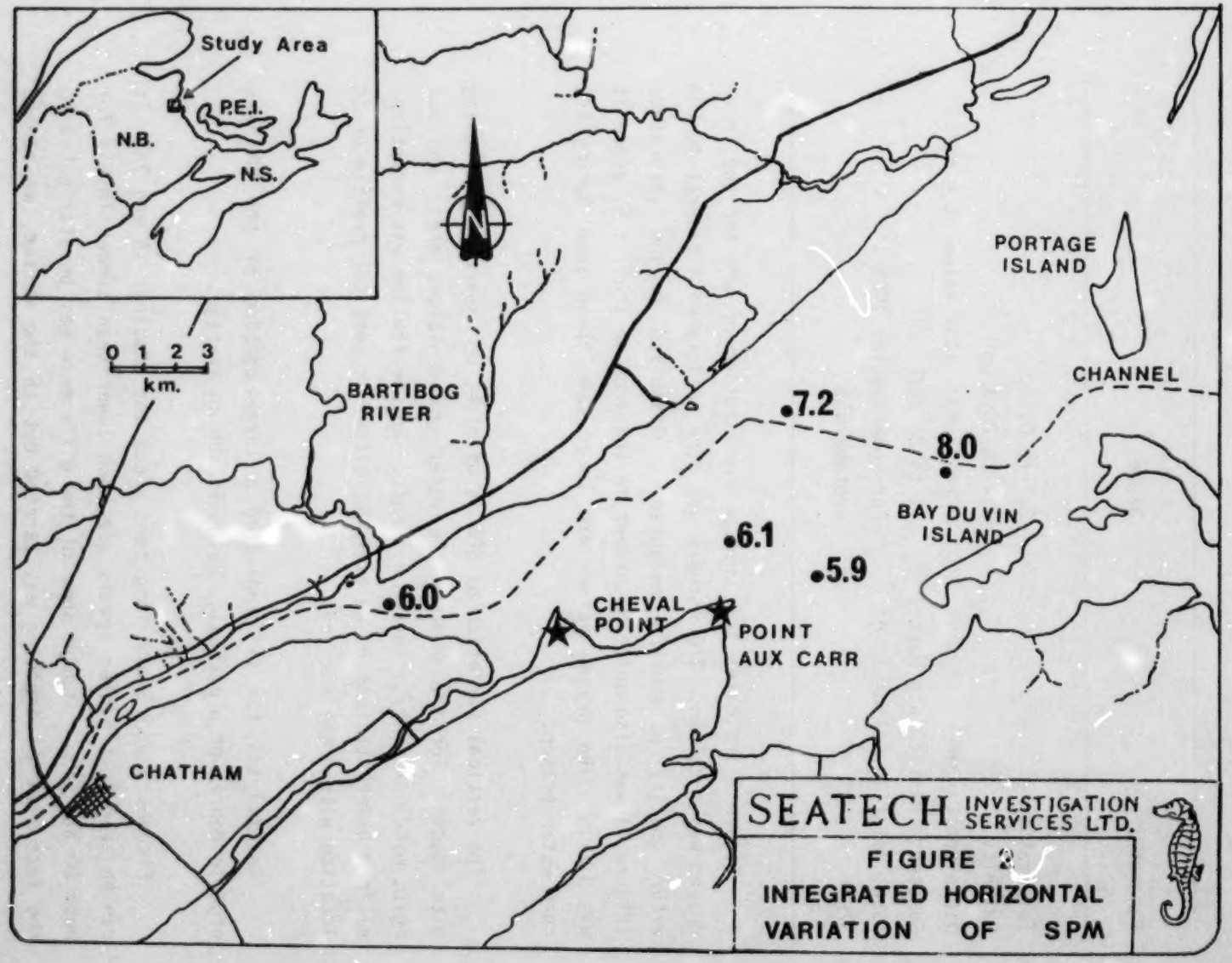

Study Area
P.E.I.
N.B.
N.S.
N
0 1 2 3
km.
BARTIBOG
RIVER
PORTAGE
ISLAND
CHANNEL
7.2
8.0
BAY DU VIN
ISLAND
6.1
5.9
6.0
CHEVAL
POINT
POINT
AUX CARR
CHATHAM
SEATECH INVESTIGATION
SERVICES LTD.
FIGURE 3
INTEGRATED HORIZONTAL
VARIATION OF SPM

TABLE 1. DATA RANGES

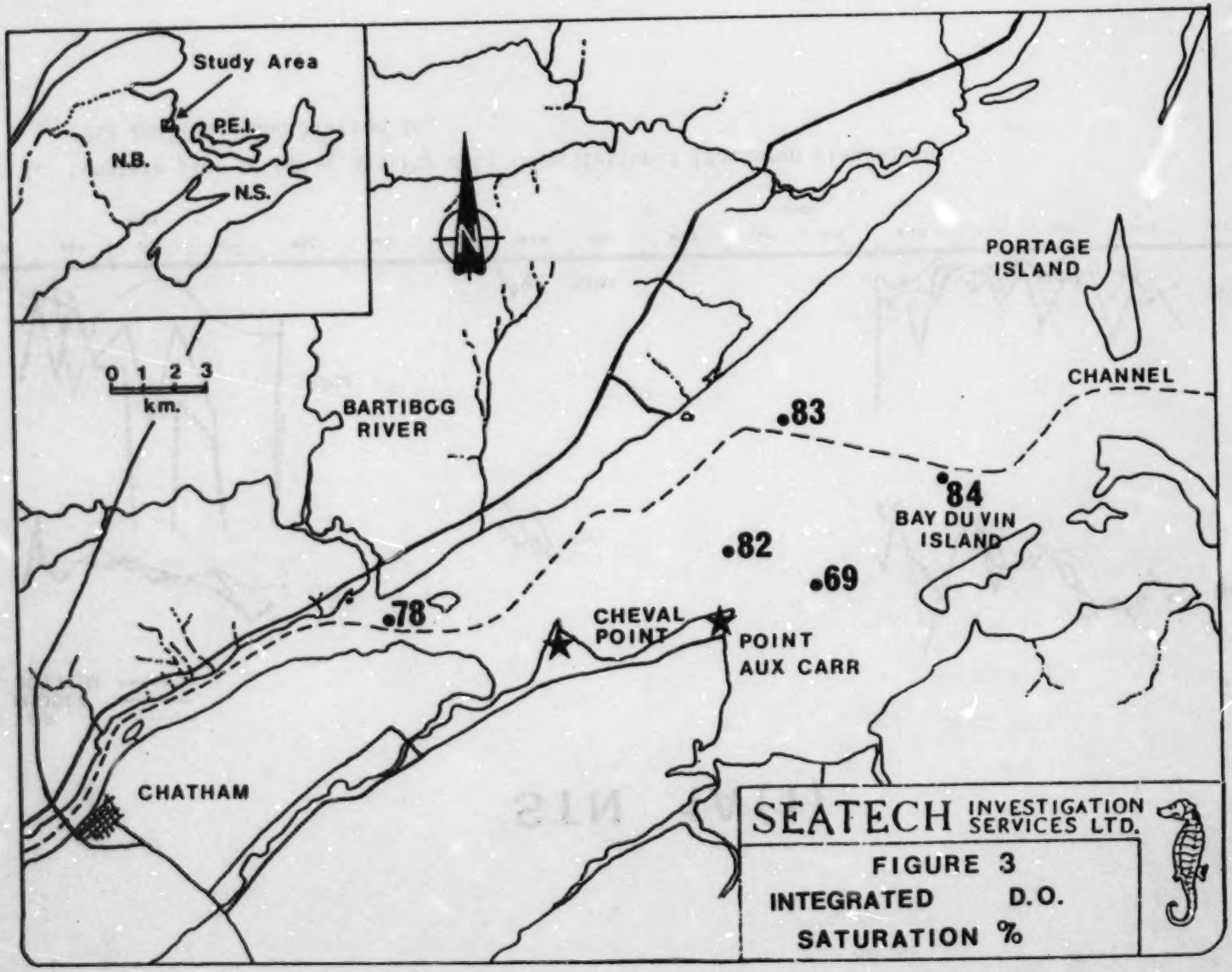
Parameter	Range
Temperature	-2.1 to 0.1°C
Salinity	1.7 to 26.1 ppt
Dissolved Oxygen	9 to 13 mg/L (one value at 6 mg/L)
Suspended Particulate Matter	1 to 36 mg/L
Total Volatile Solids (% of SPM)	For some samples 100% Average 55%

Figure 2 indicates the average distribution of SPM for the integrated water column. The estuary was very uniform with respect to the water quality parameters measured. Dissolved oxygen saturation (Figure 3) was also uniform, except in the area of station 5, where it was lower. The oxygen values are lower than those seen during the open water season.

The vertical variation of SPM is as might be expected, increasing with depth. For the estuary the water column values are: top 5.1 mg/L, middle 7.1 mg/L, bottom 8.1 mg/L. No one station was exceptional from other stations on an average, either in vertical profile or in location within the estuary.

An analysis for TVS indicated a large portion of the SPM was organic debris or planktonic, being 55% on an average.

Figures 4 and 5 are long term plots for stations 1A and 2A. It can be seen that winter levels are much lower than summer levels for both DO and SPM. Though some of the difference may be attributed to the fact that no dredging was carried out in the winter, we cannot


Study Area
P.E.I.
N.B.
N.S.
N
0 1 2 3
km.
BARTIBOG
RIVER
PORTAGE
ISLAND
CHANNEL
83
84
BAY DU VIN
ISLAND
82
69
78
CHEVAL
POINT
POINT
AUX CARR
CHATHAM
SEATECH INVESTIGATION SERVICES LTD.
FIGURE 3
INTEGRATED D.O.
SATURATION %

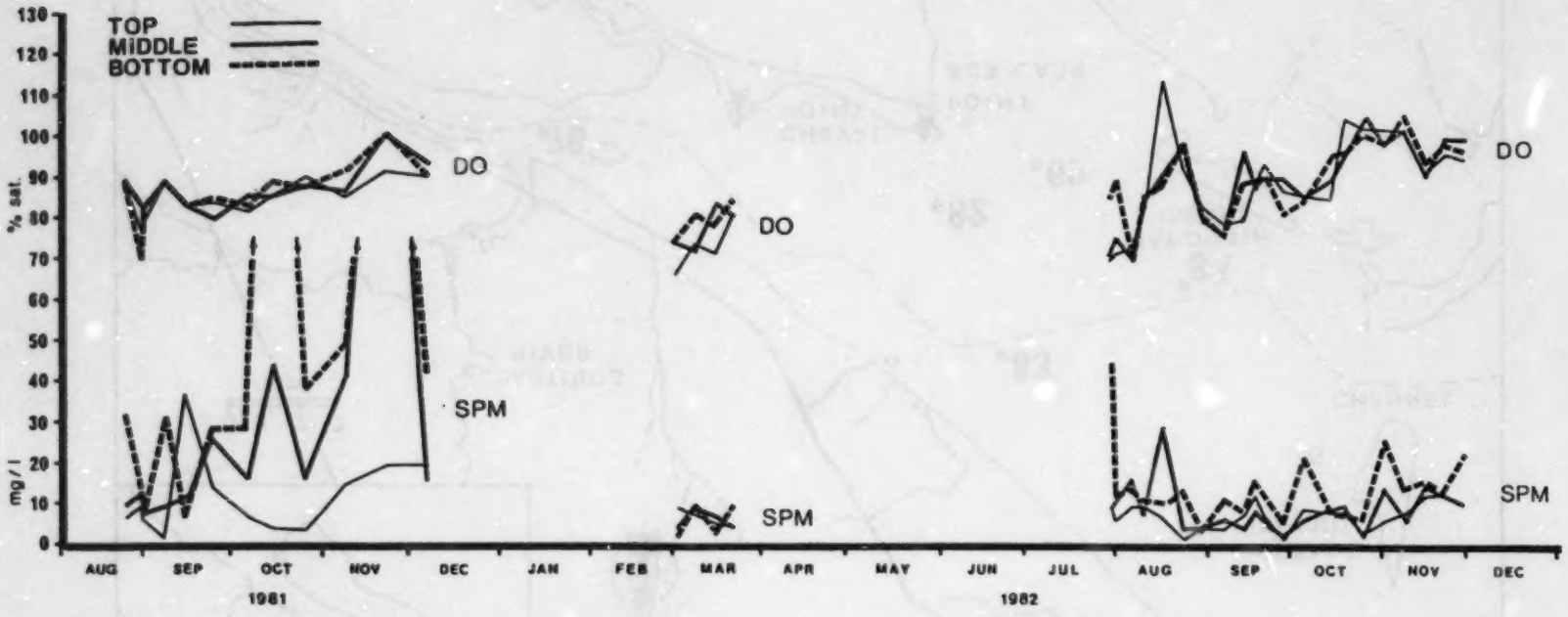


Figure 4. Longterm plot of water quality data from Station 1 (MacLaren Plansearch, 1982 and 1983) and Station 1A.

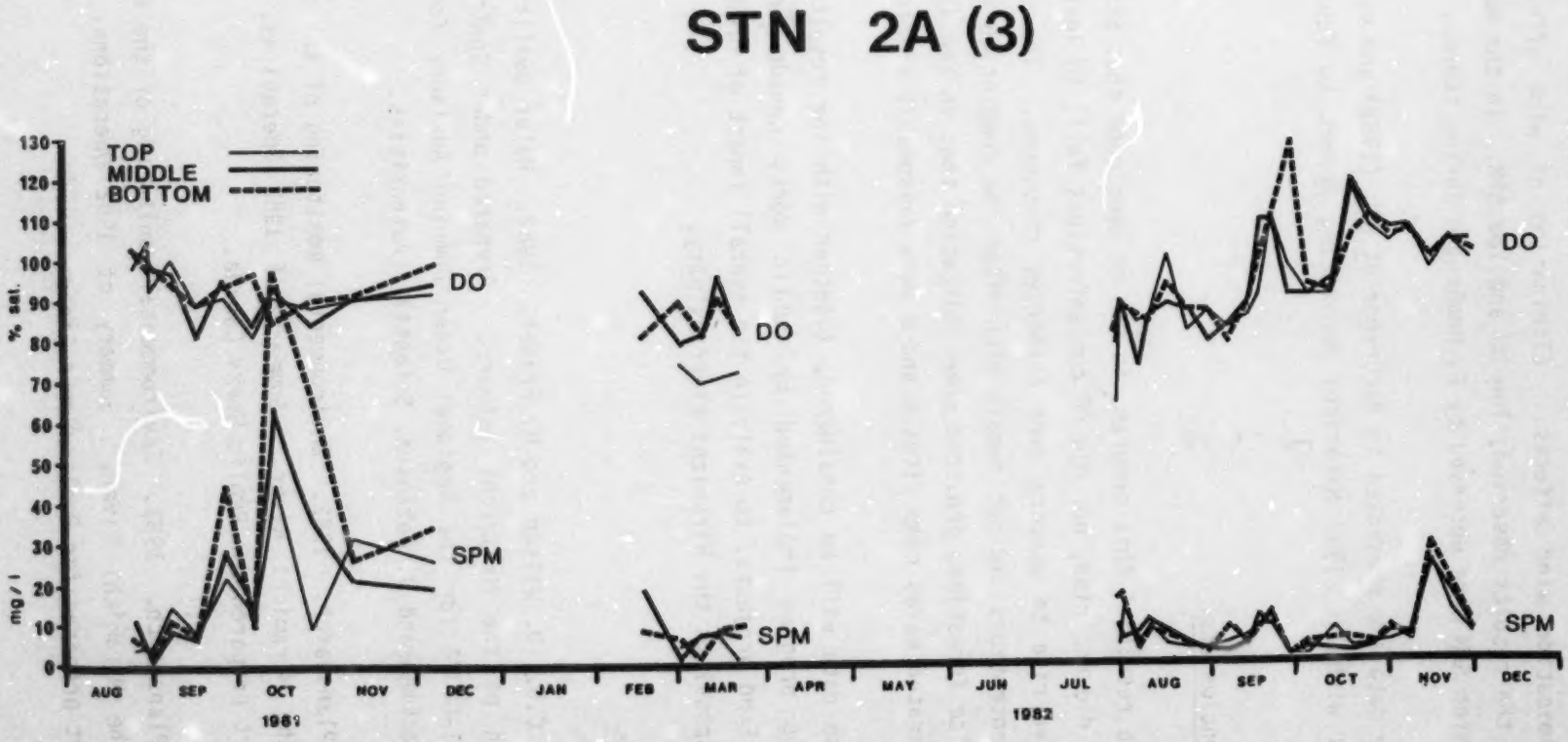


Figure 5 Longterm plots of water quality data from Station 2A and the nearby Station 3 of MacLaren Plansearch (1982 and 1983).

discount effects of ice on river flow, or probably more importantly the elimination wind effects. Elimination of wind effects would produce the results observed; low DO and low SPM. In the summer, low DO and high SPM were observed by C. MacGregor during storms.

The data are presented in MacGregor et al. (1982) and will be integrated with the 1982 Miramichi Monitoring Report to Public Works Canada.

8.4 Conclusions

As a result of this program, it can be concluded that SPM concentrations did not rise, nor did DO concentrations fall, to levels which would give rise to concern over fisheries resources. The fact that SPM concentrations did not remain high after the completion of dredging and ice formation, provided some indication that in the absence of wind generated waves dump sites A and B were reasonably stable.

These data will be considered, together with the results of the monitoring program implemented by Public Works Canada and other Re earch Fund projects, to evaluate the overall impact of dredging and spoil disposal on the Miramichi River estuary.

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MacLaren Plansearch. 1982. Environmental monitoring of the dredging of the Miramichi River. Summary of 1981 Operations. Draft report prepared for Public Works Canada.

MacLaren Plansearch. 1983. Environmental monitoring of the dredging of the Miramichi River. Summary of 1982 Operations. Draft report prepared for Public Works Canada.

9. A REVIEW OF LEAD IN COASTAL SEDIMENTS OF THE ATLANTIC REGION WITH RECOMMENDATIONS RELATED TO THE OCEAN DUMPING CONTROL ACT - STATUS REPORT

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The principal contract requirement is an analysis of the quantitative distribution of lead in marine nearshore sediments of Atlantic Canada. The data for this mission have been extracted from files provided by the Environmental Protection Service, Department of Environment regional office, Dartmouth, Nova Scotia. These data have been condensed from the reports of private-sector contractors retained to analyze the content of heavy metals in such sediments, preparatory to the initiation of coastal dumping procedures by industrial organizations and by operational branches of public service departments, primarily the Department of Public Works. Such information provides the basis for an evaluation of probable deleterious effects that could arise from redistribution of these pollutants during the disturbance of relatively stabilized sediments.

The values for lead content of such sediments have been extracted from nearly 600 applications for dumping permits issued by the Department of Environment, together with analysts' estimates of the composition of the sediments, classified by percentages of gravel, sand, silt and clay. Retention of precipitated lead compounds by absorption is considerably governed by particle-size, clay having the greatest affinity for such precipitates. These data have been segregated according to provincial coastline and by specific site. The sedimentary lead content for each of these sites will be assigned to maps to expedite the identification of areas of excesssive levels of lead. Equally important would be the deliniation of any coastal sediments that have no detectable accumulation of lead.

In addition to these data, any available records of lead contents in eastern Canadian nearshore sediments that are housed in the various units of the Bedford Institute of Oceanography will be solicited for incorporation in the evaluation.

At this time, 495 references have been identified that consider lead content of marine inshore water and sediments. Approximately 40% of these were included in the 1980 evaluation, "Lead in Canadian and other estuarine and marine nearshore sediments: a literature review".[1]. About 20% of the total are irrelevant because they treat only analytical procedures. Of the remainder, only a few contain examinations of the lead content of eastern Canadian coastal sediments. This information and any other that is pertinent to this region will be drawn together to form a supplement to the earlier 1980 report.

It is anticipated that further recommendations concerning the disposition of lead bearing wastes and dredge-spoil by deposition on existing nearshore sediments of Canadian coastal waters will be generated and presented in the final report.

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[1]prepared under Contract OSC79-00256

10. ATLANTIC REGION LABORATORY EVALUATION PROGRAM

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Laboratory Division
Environmental Protection Service
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10.1 Introduction

This is an on-going quality assurance program involving quality control checks, methodology evaluation, instrument calibration, use of reference materials, general housekeeping and the like--the overall objective being generation of good quality data and their inter-laboratory comparability. Although the program is of general application, it was specifically developed with the enforcement of the Ocean Dumping Control Act and its regulations in mind. During the past few years, since the inception of the program, information exchange and general communication between various laboratories in the Region and outside, have improved significantly. This is reflected in several quality control round robins (Table 1), a successful quality control workshop and formal and informal visits to each others' laboratories.

The program has a special significance for private consulting laboratories. Most of the laboratory work generated in conjunction with dredging/dumping operations by agencies such as Public Works Canada (PWC) is contracted out to private laboratories, although EPS has an auditing role to play pertaining to these measurements. Obviously, it will be preferable to send work to a laboratory which can consistently produce quality data. Such contracts also act as catalysts to methodology development to meet future requirements. In other words, it is in the interest of private laboratories, in order to attract contractual work, to diversify and improve their methodology and participate and perform well in quality control round robins.

10.2 Activities during the Fiscal Year 1982-83

There were three main thrusts during the year. These are on-going quality control round robins, advice/assistance to PWC and impact in other regions/HQs, other government departments and NRC.

10.2.1 PCB Quality Control Round Robin

A quality control round robin involving PCB samples was organized in the fall, in co-operation with National Research Council-Atlantic Region Laboratory (NRC-ARL) in Halifax. The participation was solicited from both government and private laboratories. NRC is preparing the report. In this connection, it is interesting to note that a private laboratory in British Columbia, on its own, showed interest and participated in this quality control round robin.

10.2.2 Advice/Assistance to Public Works Canada

A joint meeting of the RODAC and Laboratory Evaluation Committee was held in June to explore various ways the latter can assist PWC. At the meeting, it was noted that the Laboratory Evaluation Committee should be requested to provide advice to PWC and other interested agencies on a continuing basis, especially in technical/scientific areas. In an effort to meet this request, draft guidelines for sample collection and analysis were prepared. These draft guidelines, which can be modified as need arises, are intended to be used by agencies such as PWC in their contractual work. The draft guidelines are presented in Appendix I.

Another aspect of the advisory role of the Laboratory Evaluation Committee resulted in collection and preparation of reference environmental samples for use by PWC as internal check

samples. This project was initiated jointly with NRC-ARL, Halifax. The funds for the project were procured from WPCD, Ottawa. The project is nearing completion. Preliminary inquiries are being made with several recognized laboratories with a view to seek their co-operation in analyzing these samples and producing reliable analytical data.

10.2.3 Impact in other Regions/Departments

The Laboratory Evaluation Program has been instrumental in generating interest in other regions, both in private laboratories and in other government departments/agencies, e.g. DFO and NRC. To this end, we have received several inquiries from Quebec, Ontario and the West Coast, to name a few. This program has been one of the catalysts in generating interest in quality assurance protocols covering a wide variety of program areas, e.g. Long Range Transport of Air Pollutants (LRTAP) and pesticides.

In conclusion, the year can be termed as successful. Some new ground was broken and we have been receiving excellent co-operation from every quarter. I would like to thank all those who have helped make this program very exciting and challenging.

Table 1. Summary of Quality Control Round Robins Conducted by the Laboratory Evaluation Committee

QUALITY CONTROL NUMBER	PARAMETERS	PARTICIPATION	COMMENTS
1.	Trace metals in sediments (Cd,Co, Cu,Ni,Pb,V and Zn)	16 laboratories including one from outside the region	Variable performance, very few laboratories capable of low level Cd-Measurements
2.	Trace metals in sediments (Cd,Cu, Pb, and Zn)	7 laboratories	Cd-Measurements still pose problems to some laboratories
3.	Polychlorinated Biphenyls in sediments (PCBs)	Information being collated; preliminary evaluation indicates deficiencies in these measurements, especially in the private sector	
4.	Seawater standards	Under advisement	
5.	Analysis of Environmental Samples	After the samples have been prepared (under contract), it is expected that the analyses will be carried out by some reputed laboratories with a view to obtaining reliable data. (This, strictly speaking, does not constitute a quality control round robin).	

GUIDELINES FOR SAMPLE COLLECTION, ANALYSIS AND DATA REPORTING IN SUPPORT OF OCEAN DUMPING PERMIT APPLICATIONS (DRAFT)

1. It is required that sediment samples representative of the material to be dredged be obtained and stored in a manner which will not permanently alter the physical or chemical nature of the sample.

2. Where samples may be less than representative, they should be taken from areas which are judged likely to be the most heavily contaminated (e.g. surface samples adjacent to a wharf).

3. Where extensive areas are to be dredged and where contamination is likely to have occurred, core sampling should be employed at sample stations which are in a grid pattern. A specific sampling program may best be developed in direct co-operation with the EPS of Environment Canada.

4. Analyses should be carried out according to the methodologies recommended in the Ocean Dumping Report #1, A. Walton, 1978. No other methodology should be employed without consultation with the chairman of the RODAC or his representatives. Instrumentation must be equal to or of superior quality to that referred to in the reference report.

5. Analysts are required to calibrate their instruments/equipment using acceptable reference materials such as are obtainable from the National Research Council (NRC) Analytical Chemistry Standards program, Atlantic Research Laboratory. Details of calibration procedures and results shall be submitted with the data.

6. It is required that analysts carry out and report on duplicate analyses of at least one tenth of their samples as an internal check on the reproducibility of results.

7. It is required that any sample remaining after analysis be retained in a suitably preserved form until either an Ocean Dumping Permit has been issued or notice has been given by the Regulatory Authority.

8. The laboratory performing the analyses must have a qualified professional chemist on staff to validate the analyses.

9. All data supporting the application must include means, variances and the detection limits for the parameters determined.

10. Data must be reported on a dry weight basis.

11. The contracting laboratory must participate in periodic quality control round-robins and perform satisfactorily in order to be eligible to bid for contracts.

11. STUDY OF THE EFFECTS OF CHANNEL DREDGING ON THE SEDIMENTOLOGICAL ENVIRONMENT OF THE MIRAMICHI ESTUARY (STATUS REPORT)

T.G. Milligan[1], K. Kranck[1], P. Dunham*, D. Nelson*
[1]Coastal Oceanography * Geomarine Associates

In 1982 a project was initiated to assess changes in bottom sediment stability in the Miramichi Estuary. This project is being carried out by the Coastal Oceanography section of the Bedford Institute (BIO) with field work and analysis contracted to Geomarine Associates, Halifax.

11.1 Purpose

The purpose of the study is to try to determine what, if any, are the changes in the sediment regimes of the estuary since the start of dredging within the inner bay. The results of this project will be compared with those of a similar study carried out in 1973 to determine if the dredged material has remained at the chosen dump sites, whether the dump sites are stable or being eroded and what the effects have been on the suspended particulate matter (SPM) values in the water column in the bay.

11.2 Methods

11.2.1 Bottom Sediments

Bottom sediment samples were obtained at 64 locations using an Eckman grab (Figs. 1 & 2). Sample locations were fixed using Loran C. Care was taken in handling the samples to keep the surface layer intact to allow a volumetric subsample to be taken. A 0.1 ml subsample was taken from the surface of each grab using a piston type minicorer designed at BIO. These volumetric samples will be analyzed for particle size distribution and density. Two larger samples were

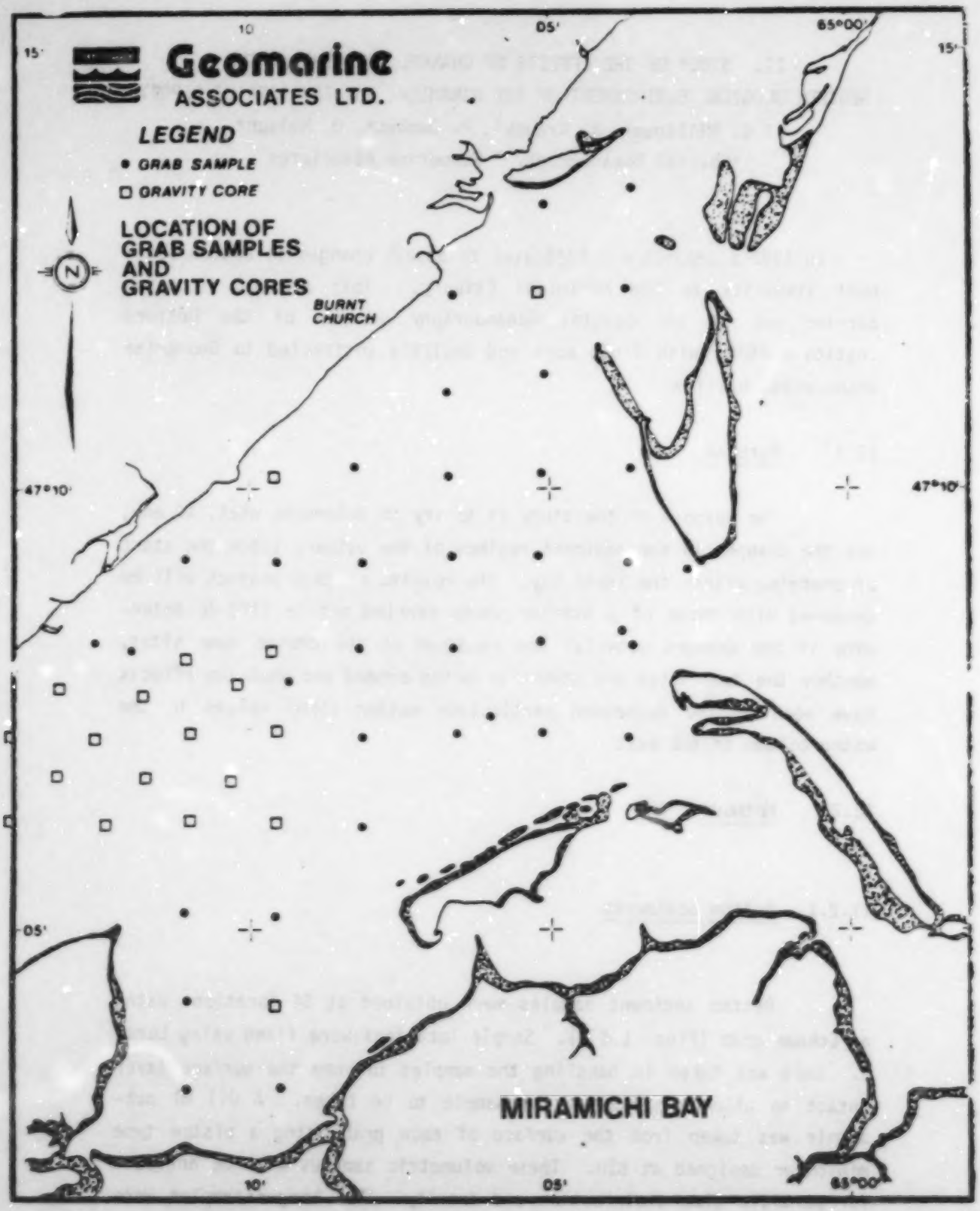

Geomarine
ASSOCIATES LTD.
LEGEND
GRAB SAMPLE
GRAVITY CORE
LOCATION OF GRAB SAMPLES AND GRAVITY CORES
BURNT CHURCH
MIRAMICHI BAY
47°10'
65°00'
15'
10'
05'

Figure 1

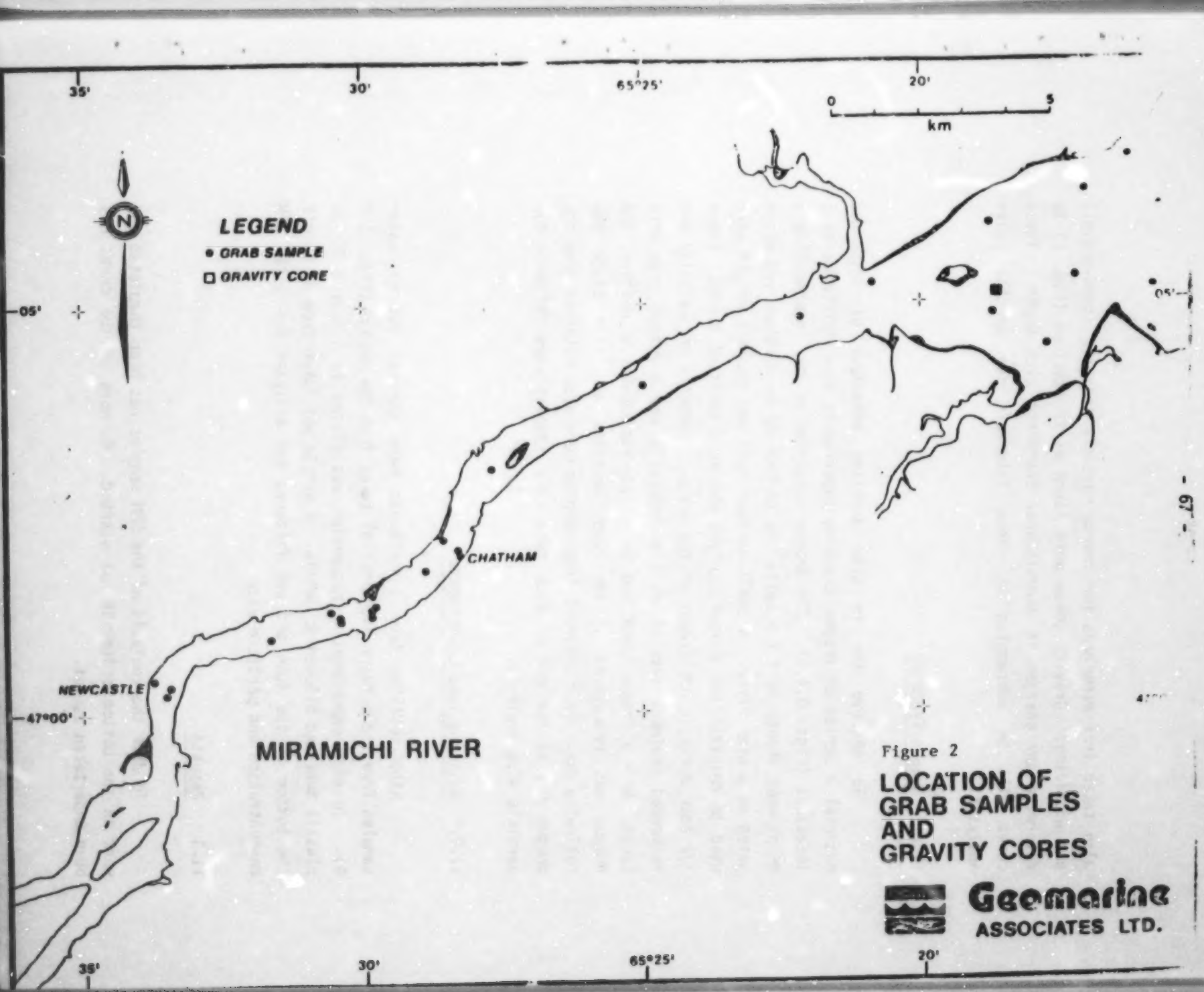


Figure 2

LOCATION OF GRAB SAMPLES AND GRAVITY CORES

Geomarine ASSOCIATES LTD.

also taken from each grab for coarse particle analysis (sand-gravel) and archiving. Gravity cores were taken at 22 stations (Fig. 1) to determine any changes in depositional character with depth. These cores will be subsampled at close intervals for particle size analysis.

11.2.2 Drogue Tracking

To observe the in situ settling behaviour of suspended material a series of drogue tracking experiments were initiated at 5 locations (Figs. 3,4,5). The drogue consisted of two intersecting 1 m^2 plywood sheets held 1 m below the surface on an aluminum rod which acted as a high flyer. A small surface buoy and counter weight were used to maintain the drogue upright and at a constant depth. Every 1/2 hour during a deployment of the drogue, temperature, salinity and suspended sediment samples at 1 m intervals and a bottom grab were taken. When a drogue track had to be interrupted due to weather, the drogue was redeployed at the same location and tide state the following day. Four sediment trap samples were also obtained from the drogue and at the end of each run. All samples were filtered for particle size analysis.

11.2.3 Settling Tube Experiments

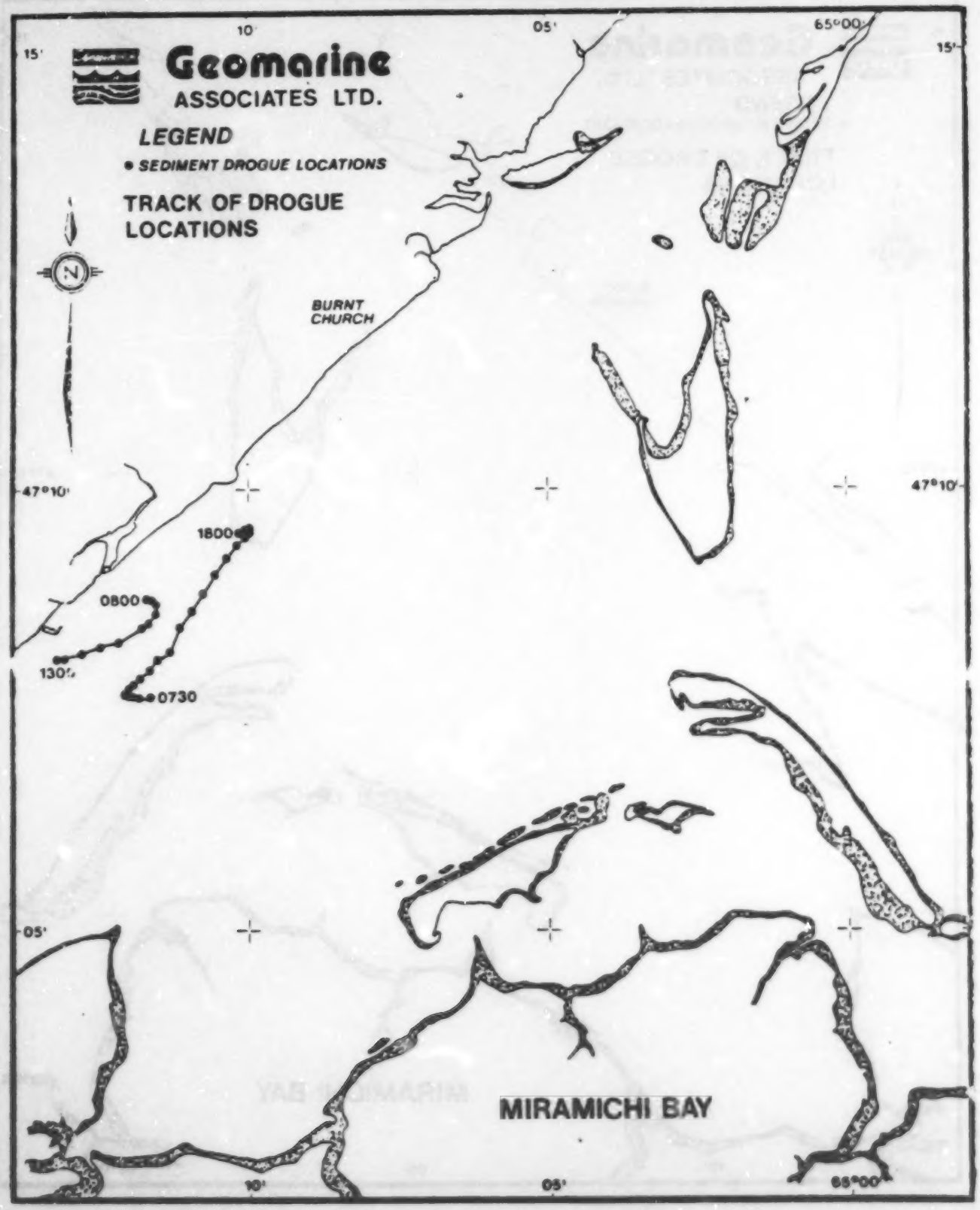
Nine settling tube experiments were carried out on water samples from the estuary and material taken from the dredge (Figs. 3 & 4). In each experiment a suspension was placed in 1.5 m x 80 cm plastic tube and allowed to settle. A sample was taken from 30 cm off the bottom of the tube and was filtered and analyzed for total SPM concentration and particle size.

11.3 Results

To date the analysis of the SPM samples has been completed and work on the bottom sediments has started. No work on the cores has been undertaken as yet.

Geomarine
ASSOCIATES LTD.
LEGEND
SEDIMENT DROGUE LOCATIONS
TRACK OF DROGUE LOCATIONS
N
BURNT CHURCH
47°10'
1630
1830
1030
0730
MIRAMICHI BAY
10'
05'
65°00'
15'

Figure 3


Geomarine
ASSOCIATES LTD.
LEGEND
• SEDIMENT DROGUE LOCATIONS
TRACK OF DROGUE LOCATIONS
N
BURNT CHURCH
1800
0800
1300
0730
MIRAMICHI BAY
10'
05'
65°00'
15'
47°10'

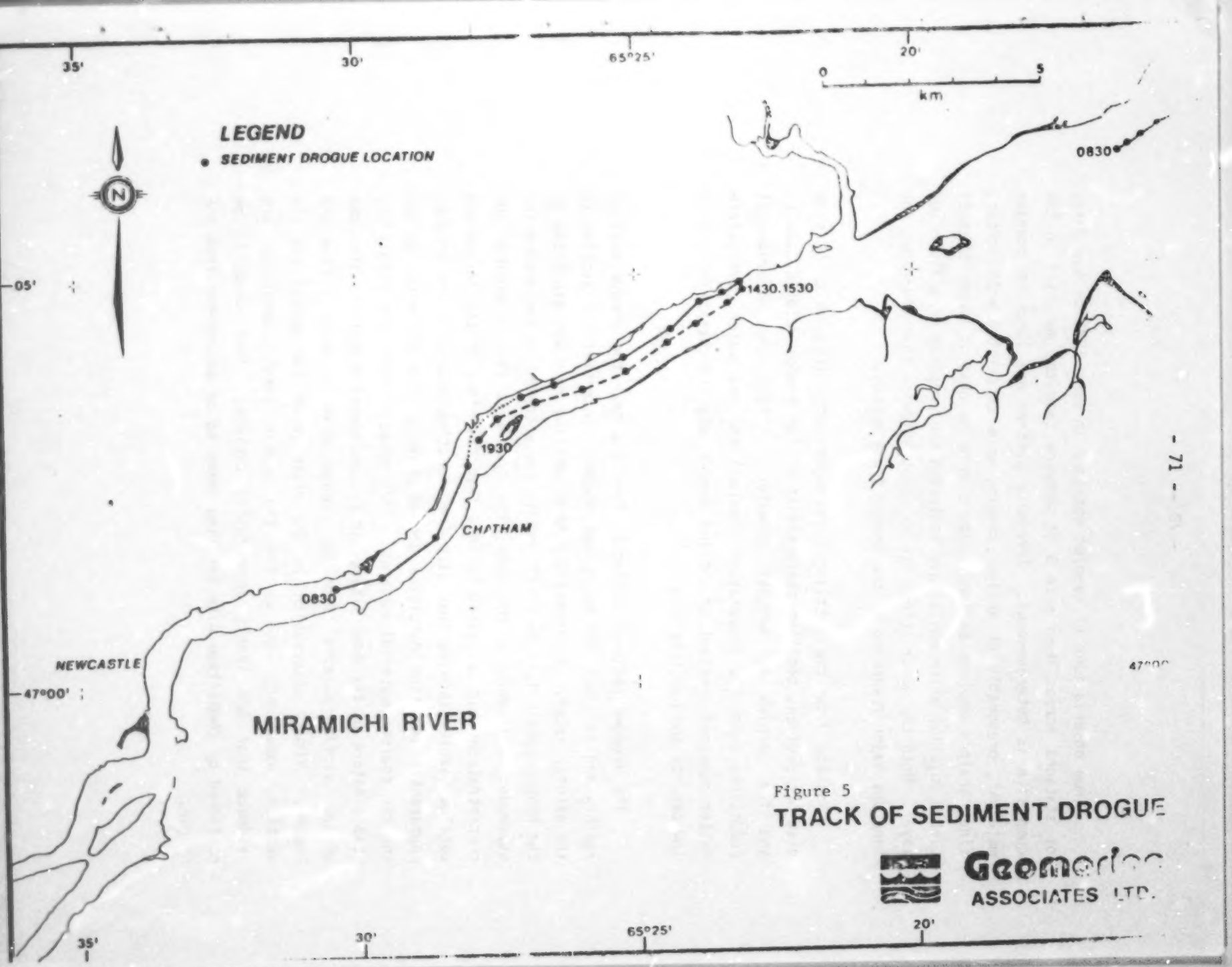


Figure 5
TRACK OF SEDIMENT DROGUE

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ASSOCIATES LTD.

From observations of samples obtained in June 1982 on two lines of stations across dump site B it appears that the material on the dump site is heterogeneous. Irregular patches and lumps of coarser material, presumably of dredged origin, were associated with softer, finer grained ambient sediment. There were no obvious signs of soft turbid material which would have indicated the presence of a fluid mud layer. Both the observations are apparent evidence that there has not been any major reworking of the dredge spoil mounds.

Results from the settling tube experiments (Fig. 6 & 7) show distinct sediment settling characteristics for dredge related samples and for samples of natural seawater. Under the experimental conditions used (no temperature control) the sea water particulate matter remained constant or settled very slowly indicating relatively low density and particle size.

The dredged sediment collected from and near the dredge settled rapidly and in about 100 hours had reached concentrations similar to the natural water. An especially high settling rate was exhibited by the hopper sample i.e. material gravity concentrated in the dredge for subsequent transport to the dump site. In less than 5 minutes the concentrations had decreased to less than half that of the inflow and outflow samples showing that size fractionation occurs in the hopper. Appparently the fine particles are discharged into the water column and the coarser material remains. This helps explain the relatively stable nature of the dump sites. To be considered though, is the fate of the overflow material from the dredge which is skimmed from the hopper. Visual observation in the vicinity of the dredge and the settling experiment results for the sample taken downstream are evidence that SPM levels drop fairly rapidly. This needs to be confirmed by comparison with settling rates to be determined from the drogue.

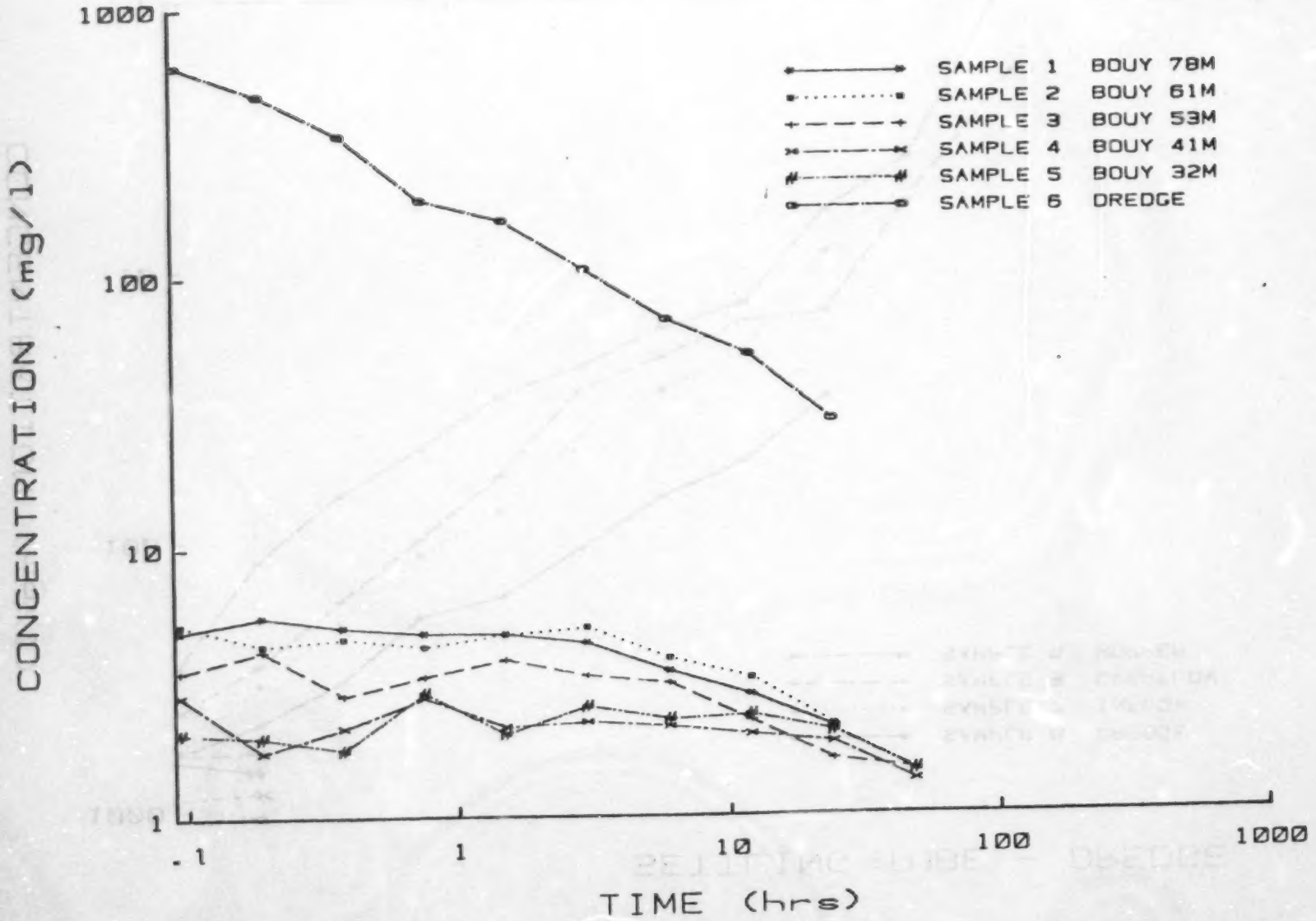
SETTLING TUBE - OPEN WATER
SAMPLE 1 BOUY 78M
SAMPLE 2 BOUY 61M
SAMPLE 3 BOUY 53M
SAMPLE 4 BOUY 41M
SAMPLE 5 BOUY 32M
SAMPLE 6 DREDGE
1000
100
10
1
CONCENTRATION (mg/l)
.1
1
10
100
1000
TIME (hrs)

Figure 6

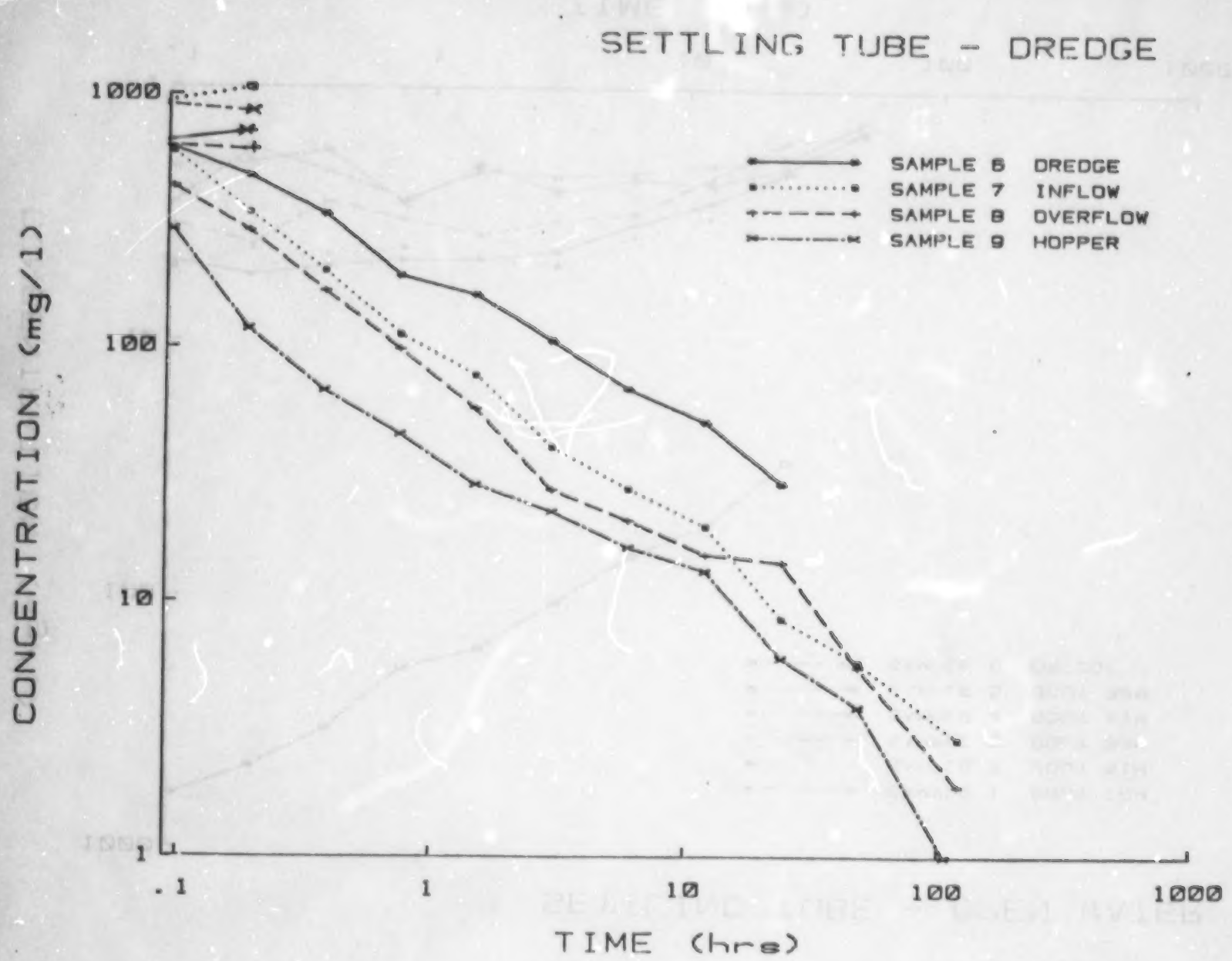
SETTLING TUBE - DREDGE
SAMPLE 6 DREDGE
SAMPLE 7 INFLOW
SAMPLE 8 OVERFLOW
SAMPLE 9 HOPPER
CONCENTRATION (mg/l)
1000
100
10
1
.1
1
10
100
1000
TIME (hrs)

Figure 7

APPENDIX I

LIST OF WORKSHOP ATTENDEES

Arseneault, N., PWC Saint John, NB.
Bernstein, B.B., Welsford Research Group, Halifax, N.S.
Best, P., EPS St. Johns, Nfld.
Bezanson, D., Maritime Scientific Services, Dartmouth, N.S.
Bradley, J.R., Canadian Coast Guard, Dartmouth, N.S.
Charron, R.L., Brunswick Mining and Smelting, Belledune, N.B.
Duncan, G., PWC, Ottawa, Ont.
Dunham, D., Geomarine Associates Ltd., Halifax, N.S.
Elner, R.W., DFO, St. Andrews, N.B.
Feicht, A., Atlantic Analytical Services, Saint John, N.B.
Hamet, S., DFO, St. Andrews, N.B.
Hebda, A., Seatech Ltd., Halifax, N.S.
Hord, H., DFO, St. Andrews, N.B.
Jordan, F., DFO, St. Andrews, N.B.
Lord, W., PWC, Saint John, N.B.
MacGregor, C.D., Seatech Ltd., Halifax, N.S.
MacGougan, J., PWC, Saint John, N.B.
MacPherson, T., Nova Scotia Department of Environment, Halifax, N.S.
McIver, A.R., EPS, Dartmouth, N.S.
McLeese, D., DFO, St. Andrews, N.B.
Milligan, T., DFO, Bedford Institute, Dartmouth, N.S.
Packman, G.A., EPS, Dartmouth, N.S.
Prairie, R., Noranda Research, Pointe Claire, P.Q.
Ray, S., DFO, St. Andrews, N.B.
Riley, D., DFO, Halifax, N.S.
Samant, H.S., EPS, Dartmouth, N.S.
Scarratt, D.J., DFO, St. Andrews, N.B.

Tay, K.L., EPS, Dartmouth, N.S.
Welsford, R., Welsford Research Group, Halifax, N.S.
Wheeland, K., Noranda Research, Pointe Claire, P.Q.
Wildish, D., DFO, St. Andrews, N.B.

APPENDIX II
OCEAN DUMPING RESEARCH FUND

1. 1981/82 PROJECTS

(i) S.N. Messieh. Impact of dredge spoil disposal on the Miramichi Bay herring fishery.
Ocean Dumping Research Fund: $22,000

(ii) G.A. Packman, D. Bezanson and K.L. Tay. Bay of Chaleur dump site studies.
Ocean Dumping Research Fund: $10,000

(iii) D.W. McLeese and S. Ray. Assessment of Saint John Harbour impacts of dumping at the Black Point dump site.
Ocean Dumping Research Fund: $14,000

(iv) S. Ray and D.W. McLeese. Bioavailability of cadmium and zinc from lead and zinc concentrates.
Ocean Dumping Research Fund: $15,000

(v) R.W. Elner. Investigation into the direct and indirect effects of ocean dumping on lobster ecology and habitat.
Ocean Dumping Research Fund: $ 7,500

(vi) D. Scarratt. Analysis of stomach contents of smelt from the Miramichi River estuary.
Ocean Dumping Research Fund: $ 5,500

(vii) D.J. Wildish. Analysis of avoidance behaviour of smelt, tomcod, and gaspereau in Miramichi dredge spoil plumes.
Ocean Dumping Research Fund: $ 5,500

2. 1982/83 PROJECTS

(i) G.A. Packman and D. Bezanson. Winter water quality studies in the Miramichi River estuary.

Ocean Dumping Research Fund: $ 7,000

(ii) K.L. Tay and T. Garside. A review of lead in coastal sediments of the Atlantic Region.

Ocean Dumping Research Fund: $ 2,000

(iii) K. Kranck. Assessment of changes in bottom sediment stability in the Miramichi estuary.

Ocean Dumping Research Fund: $40,000

(iv) D. McLeese. Toxicological significance of concentration of contaminants.

Ocean Dumping Research Fund: $15,000